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# JOURNAL OF SOUTH AFRICAN BOTANY

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# JOURNAL OF SOUTH AFRICAN BOTANY

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THIS VOLUME IS DEDICATED TO

MARGARET RUTHERFORD LEVYNS (1890- )

D.Sc. (Cape), F.R.S.S.Af.

(*Lecturer in Botany at University of Cape Town, 1917-1946*)

an outstanding research worker, student of the Cape flora and a teacher who has inspired many generations of Botany students, author of very many scientific publications, a major contributor to the *Flora of the Cape Peninsula* (1951) as well as the *Encyclopaedia of South Africa*, honoured by the Royal Society of South Africa in 1963 as the first-ever Lady President, holder of the Queen Victoria Scholarship, the 1851 Exhibition and the Cross Scholarships, the Bertha Stoneman Award and the South African Medal, Honorary Life Member of the Botanical Society of South Africa.

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A NEW SPECIES OF HAWORTHIA

C. L. SCOTT

**Haworthia baylissii** C. L. Scott sp. nov. (Liliaceae-Aloineae) Sect. Muticae).—*Foliorum* rosula acaulescens, fere 7 cm diam, basi prolifera, *folia* circa 25, fere 4 cm longa, 15 mm lata, supra plana vel concava, lineis 10 ruber indistinate; et maculis elongatis albides instructa, *subtus* valde convexa et maculis elongatis albides instructa, *pedunculus* simplex teres, 1 mm diam, 14 cm longus, racemo incluso, claro-fuscus, *racemus* longus 14 cm, flores 6, 1 apertus, *pedicelli* longi 3 mm, diam, 1 mm virides, *bracteae steriles* 11, *bracteae fertilis* longae 3 mm, *perianthium* longum 13 mm, basi diam, 4 mm album, *ovarium* longum 2½ mm diam, 1½ mm viride, *stylus* longus 1 mm curvatus, albido.

Rosette acaulescent, up to 7 cm in diam, proliferous from the base and forming clusters.

*Leaves* about 25, spirally arranged in 8 whorls the young ± erect to slightly recurved, the old patent, much recurved, ± firm, lanceolate, about 4 cm long, up to 15 mm broad, 4 mm thick measured at the base of the leaf, acuminate, falcate, dull, dark green; *face* ± flat—slightly rounded with a prominent centrally situated midrib in the upper ¾, dull, green; 10 indistinct smudgy greenish lines, smooth, with many short longitudinal whitish flecks, with a few minute pellucid rounded markings in longitudinal rows; *back*, rounded, smooth, 8 indistinct greenish lines, dull, green; *keel* 1 centrally situated and armed with ¼ mm long transparent teeth; *margins* acute, beset with ¼ mm long transparent teeth, irregularly spaced; *end-awn* 5 mm long, white, deciduous.

*Peduncle* simple, flattened low down, terete, 1 mm in diam and up to 14 cm long including the raceme, light brown, sterile bracts about 11, 5 mm long, the lowest 23 mm from the base of the peduncle; *raceme* up to 3 cm long, 1 mm in

diam about 6 spirally arranged flowers and buds, 1 open at a time; *fertile bracts* 3 mm long, deltoid, acuminate, white, papery, not stipitate; *sterile bracts* 11, up to 5 mm long, white, not stipitate; *pedicels* 3 mm long 1 mm in diam, grey green; *perianth* white, reddish brown and yellowish green lined, 13 mm long, the cylindrical-triangular base swelling 4 mm in diam, constricted above ovary to 3 mm. Ascending, curved, stipitate, segments free; *upper segments* recurved, narrow obtuse, spreading, channelled, face colour of two outers white, replicate, with a fine reddish brown nerve, acute; inner segment face colour white, with a medium yellowish green nerve, narrow obtuse, less recurved; *lower segments* outers spreading, recurved, face colour white, narrow, obtuse, replicate, with a fine yellowish green nerve; inner segment more recurved, channelled, narrow obtuse, face colour white, with a medium reddish brown nerve; *stamens* 4 and 5 mm long; *ovary* 3 mm long, 1½ mm diam, green; *style* white, 1 mm long, bent, not capitate.

TYPE. (C. L. Scott 796) In Nat. Herb., Pretoria.

TYPE LOCALITY. Oudekraal Zuurberge, Somerset East Division.

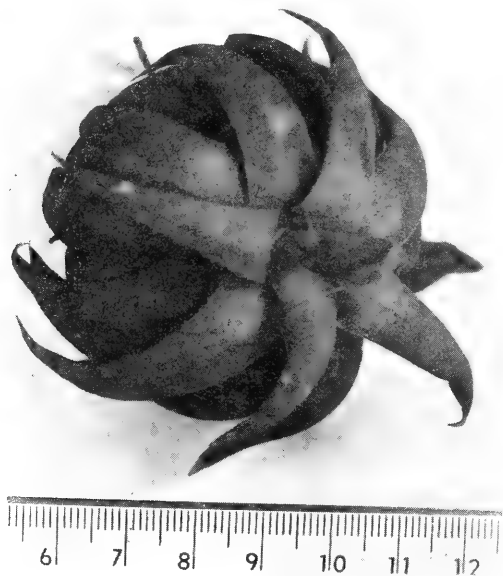


PLATE 1.  
Face view (natural size)





PLATE 2.  
Bottom view, showing roots and leaves intertwined.  
(Natural size)



PLATE 3.  
Flower spray (Actual size)

**DISTRIBUTION.** Not further known.

This distinctive species I have pleasure in naming for Colonel R. D. Bayliss of Grahamstown who collected it on the farm Oudekraal in the Somerset East Division at an altitude of 2,400 feet on 8.4.1966, where it grows on rock ledges in deep shade, and who has from time to time sent me *Haworthia* plants which he has collected. The most striking character and one by which the plant is easily recognised is that the recurved leaves give it a rounded outline. This is somewhat unusual in the genus which tends to incurve the leaves during droughts. The plants grow in deep compost soil, and leaves are retused to such an extent, that they come in contact with the roots. When grown in the open, the leaves become reddish brown, but retain their recurved character and markings.

It differs from any previously described species in the section *Muticae*.



## A NEW SPECIES OF NERINE FROM THE TRANSKEI

K. H. DOUGLAS

(Kingswood College, Grahamstown)

*Nerine gibsonii* Douglas, sp. nov., *N. appendiculatae* Bak. affinis, sed pedunculo breviori, umbella minore forma dissimili floribus paucioribus, perianthium segmentis colore dissimili, staminum appendicibus minoribus et forma dissimili dentibus paucioribus differt.

Bulbus ovoideus vel rotundatus, ad 5 cm longus, 3 cm diam, collum formans. *Folia* 1–6, plerumque synantha, filiformia, ad 32 cm longa, 3 mm lata, canolisu-lata, tortilia semel vel plura, basi rubella, apice obtusa, glabra, firma. *Inflorescentia* 4–9-flora, umbellata, patentes, ad 10 cm diam.; pedunculus teres, glaber, ad 32 cm longus, 5 mm diam; spathae valvae lanceolata, ad 4 cm longae, 1 cm latae, membranaceae; pedicelli teretes, 1·2–3 cm longi, dense glanduloso-pubescentes. *Flores* zygomorphi, patentes, ad 3·9 cm lati; segmentae lineares, ad 3 cm longae, 5 mm latae, plerumque 5 erecto-patentes (segmenta certa sub staminibus declinatis disposita), marginibus leviter undulatis, nitido-albae, ad apices pallido erubescences, dimidio basali lateris superioris lineamento mediano manifesto erubescenti, dimidio apicali lateris inferioris lineamento viridulo-rubicundo-fusco; *stamina* intima, filamentis segmentis brevioribus, spice sursum versus curvata; ultimique basis amplicatae appendicibus 2 (interdum) parvis c. 2 mm longis affinis; *ovarium* dense glanduloso-pubescente; *stylus* declinatus, tandem ultra antheras exsertus; *stigma* capitatum.

*Nerine gibsonii* Douglas sp. nov., related to *N. appendiculata* Bak. but differs in having a shorter peduncle, a smaller umbel of different form and fewer flowers, perianth segments of different colour and markings, and having smaller stamen appendages of different form and fewer teeth.

*Bulb* ovoid to rotund, up to 5 cm long and 3 cm in diam, forming a neck. *Leaves* 1–6, usually synanthous, filiform, up to 32 cm long and 3 mm wide, channelled, twisted once or more, reddish at base, apex obtuse, glabrous, firm. *Inflorescence* 4–9 flowered umbel, spreading, up to 10 cm in diam, peduncle terete, glabrous, up to 32 cm long and 5 mm in diam.; spathe valves lanceolate, up to 4 cm long and 1 cm broad, membranous; pedicels terete, 1·2–3 cm long,



PLATE I.  
*Nerine gibsonii*.

(Photo: The Botanical Research Institute from a specimen provided by G. McNeil)

densely glandular pubescent. *Flowers* with a zygomorphic perianth, spreading, up to 3.9 cm wide; segments linear, up to 3 cm long and 5 mm wide, usually 5 erectopate and the sixth situated below the declinate stamens, margins only slightly undulate, glittering white, suffused pale pink at apices, clearly defined pink medial stripe on basal half of upper side, greeny-pinkish-brown stripe on the apical half of the lower side; stamens arranged close together with the filaments shorter than the segments, curved upwards at the apex with 2 (occasionally 1) small white appendages about 2 mm long attached to each side of the widened base; ovary densely glandular pubescent, style declinate, ultimately exerted beyond the anthers, stigma capitate.

HOLOTYPE. Cape Province (Transkei), Xalanga District, mountain top near Cala, G. McNeil, Mar. 1966, NBG 85056.

The species is found on or near the summits of mountains in the Cala-Engcobo area of the Transkei at elevations of 5,000 to 6,000 ft. The vegetation is grass veld and the bulbs are usually confined to rocky outcrops facing North-east and East. The bulbs are usually found wedged between rocks.

The species was first collected by Alice Pegler (No. 1631) at Cala in Feb. 1910. This sheet is in the Bolus Herbarium. It was subsequently collected by Mr. L. F. Gibson of Engcobo in 1955 and 1956 at Mntunthloni beacon and on Qumakala Mountain: SAM 68450 and SAM 68451. The holotype, a carefully chosen representative plant, was collected by Mr. Gordon McNeil in March 1966 and this collection is in the Compton Herbarium, NBG 85056. It has also been in cultivation in Engcobo and Grahamstown for several years.

When first sent for identification it was thought to be *Nerine pancratioides* Bak. because of its white perianth segments and appendiculate stamens. Closer examination showed, however, that it lacked the dense umbel, the funnel-form perigone, and the square bifid scales of *N. pancratioides*; and that it was more closely related to *N. appendiculata* Bak.

Hybridization experiments are at present in progress in the author's garden in Grahamstown and the species appears to have been successfully crossed with both *N. flexuosa* var *alba* and with *N. appendiculata*. So far the hybrids have not flowered.

#### ACKNOWLEDGMENTS

I wish to record my very sincere thanks to all those who have helped me in this work: To the late Mr. and Mrs. L. F. Gibson for their friendship and hospitality; to Mr. Gordon McNeil for much encouragement and advice and for invaluable help with measurements and descriptions; to Dr. Codd, Dr. Killick and Mrs. Mauve of the Botanical Research Institute, and to Miss W. F. Barker of Kirstenbosch for all their help and kindly advice.



## THE REDISCOVERY OF *RHYNCHOCALYX* *LAWSONIOIDES* OLIV.

R. G. STREY AND O. A. LEISTNER

(Botanical Research Institute, Department of  
Agricultural Technical Services)

*Rhynchocalyx lawsonioides* was described by Oliver (1895) from a single gathering by John Medley Wood (No. 3124) collected "near Murchison", Natal, in April, 1884. The plant was apparently not collected again until April, 1966, while the fruit of this monotypic genus was unknown until July, 1967.

Although Oliver saw no fruit he unhesitatingly classified *Rhynchocalyx* under the Lythraceae. Koehne (1903), however, excluded it from this family as the stamens are in a single whorl opposite the petals and the ovules are "uniseriate" in each loculus. Sprague and Metcalfe (1938) pointed out that there are other undoubted members of the Lythraceae with a single whorl of stamens opposite the petals. They also observed that, although the ovules in each loculus are arranged in a more or less distinct single row, they do originate from two separate vertical axile placentae. Sprague and Metcalfe therefore agreed with Oliver (1895) in placing the genus in the Lythraceae. Phillips (1951) and Willis (1966) adopted the same view which is also subscribed to by the present authors.

On the 3rd of April, 1966, the first author and Mr. H. B. Nicholson, a keen student of the flora of Natal, collected on the farm Beacon Hill. This farm is situated some ten miles south of Izingolweni in southern Natal and was visited with the kind permission of the owner, Mr. Niemand. Small patches of forest occur in the deep ravines and kloofs descending with several steep Table Mountain Sandstone terraces towards the Mtamvuna River which forms the boundary between Natal and the Cape Province. The moist, sheltered ravines harbour a rich flora including Cape elements such as *Podalyria velutina* Burch., *Raspsalia trigyna* Duemmer, *Psoralea pinnata* L. and *Phylica paniculata* Willd. In a small ravine two trees, some 4—5 m high and covered in tiny white flowers were found: *Rhynchocalyx lawsonioides* (Strey No. 6539). A search was later undertaken for other specimens, but none have so far been found on Beacon Hill.

No fruiting material was collected during 1966, but the species was discovered in a second locality by Mr. H. B. Nicholson above the Izotsha falls some ten miles west of Port Shepstone. This area belongs to the Murchison Plains Black Wattle Company and was visited with the kind permission of the manager, Mr. T. S. Little. Only twelve specimens were found here, all growing in a woody ravine pointing east-south-east towards the distant coast in the Uvongo area. Here, *Rhynchocalyx* (Strey No. 7550) is growing together with such species as *Halleria lucida* L., *Syzygium gerrardii* (Harv.) Hochst., *Cryptocarya wyliei* Stapf and *Cunonia capensis* L. There can be little doubt that it was this area that Medley Wood referred to as "near Murchison", the type locality of *Rhynchocalyx*. The old main road went past the Murchison Mission Hospital from which the area takes its name and which is situated some two miles east of the Izotsha Gorge. At the time when Medley Wood collected in the area the flats, which are now intensively planted with sugar cane, were probably covered by grassland. The steep sides of the Gorge were presumably only partially exploited for timber and firewood and it seems reasonable to assume that they supported *Rhynchocalyx* then as they do now.

A third locality in which a few specimens of *R. lawsonioides* were recently found is at Mgongongo near Margate in the ravine of a tributary to the Mhlange River (Strey No. 7610).

At the beginning of July, 1967, the first fruiting material was found and a more complete description of the plant can now be given: *Rhynchocalyx lawsonioides* is an erect tree, 3–6 m high, with a straight bole; the bark is grey with a pink slash, rough but not deeply fissured and with very small flaking scales (Plate 1). The upper *branchlets* are opposite or in whorls of 3–5. The *leaves* are opposite and the petioles are 1.5–3 mm long; the blades are 2.5–7 cm long and 1–2.5 cm broad, narrowly elliptic-ovate and the margins are recurved and entire or sometimes notched at the apex, the upper leaf surface is dark green, slightly shiny and with a fairly prominent mid-rib and major veins, the lower surface is pale grey-green and has a prominent mid-rib. The *inflorescence* is a many-flowered panicle which is either terminal or axillary. The *flowers* are bisexual and regular and the *pedicels* are 1–3 mm long. When in bud the calyx is ovoid-globose and produced into a conical beak which is up to 1 mm long. There are six narrowly ovate-triangular *sepals* which are 0.7–1.5 mm long and fused in the lower  $\frac{1}{3}$ . The plant has six white *petals* which are 0.5–1.5 mm long and have a long, linear claw and an expanded, membranous, lobed limb; the petals alternate with the sepals. There are six *stamens* which are about as long as the petals and opposite them; the *filaments* are about as long as the anthers and glabrous; the *anthers* are broadly elliptic and 2-theous. The *fruit* is a two- (or sometimes three-) locular, dorsiventrally compressed



capsule, partially loculicidal at the apex (Fig. 1: 1, 2). It is about 5—8 mm long, 6—9 mm broad when measured across the greatest width and 2·5—3·2 mm across the narrowest width. The ripe capsules are dark straw-coloured to light reddish-brown and they are marked with more or less horizontal ribs. Each locus contains 11—17 flat, more or less obliquely ovate *seeds* which are 2·5—4 mm long and 1·8—2·3 mm broad (Fig. 1: 4). The lower  $\frac{1}{3}$  of each seed consists



PLATE 1.  
Stem of *Rhynchocalyx lawsonioides* Oliv.



ALEIDA VAN DER MERWE

FIGURE 1.  
*Rhynchocalyx lawsonioides* Oliv.: 1. Fruiting branch (natural size); 2. Ripe fruit ( $\times 4$ ); 3. Diagrammatic cross section of young fruit showing arrangement of ovules ( $\times 6$ ); 4. Seed ( $\times 5$ ).

of a thin, wing-like portion. In each loculus the horizontally orientated seeds are tightly packed in a more or less distinct vertical row with seeds alternately originating from one of the two axile placentae (Fig. 1: 3). The capsules start ripening towards the end of June and the last seeds are shed one to two months later. The ripe seeds escape through the apical slit and are dispersed by wind. Many capsules are infested with small maggots.

The genus has so far only been collected in the degree square 3030 (Port Shepstone), where it is found in sheltered spots on steep slopes along the margin of kloof forest. *R. lawsonioides* appears to be extremely rare, less than 40 specimens having come to our knowledge. There are indications that Bantu make use of the tree for various purposes and the species appears to be in real danger of eradication.

KOEHN, E. (1903), in ENGLER, A., *Das Pflanzenreich* 17:4: 272.

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# A QUANTITATIVE ECOLOGICAL INVESTIGATION OF THE KRANTZKLOOF FOREST, NATAL

E. J. MOLL

(Botanical Research Institute, Department of Agricultural Technical Services)

## ABSTRACT

A brief account of the location, topography, geology and climate of the area and a short qualitative description of the forest are given. An enumeration of the various synusiae sampled and the different parameters employed is presented. Twenty-six combinations of data were ordinated using the Wisconsin technique, and a method first employed by Woods and Moll<sup>3</sup> was used to find the most efficient ordination. Performance of selected forest species is discussed with reference to environmental data collected at each sampling site.

## INTRODUCTION

The area of forest analysed is in the Krantz-kloof Nature Reserve about 20 km WNW of Durban at the intersection of co-ordinates 29° 46' South and 30° 50' East. The forest extends in a belt along the south-facing slopes of a steep-sided river valley; the altitude varies from 300—500 m.

## PHYSIOGRAPHY

### *Topography*

The forested area is divided into two sections by a line of cliffs some 40—70 m high. Above the cliffs the forest is shorter, with rather more *Protorhus longifolia* as a canopy tree, than the forest below, which has a greater predominance of *Drypetes gerrardii* in the canopy. The ground above and below the cliffs is steep; from 20°—30°.

### *Geology.*

A thick layer of Table Mountain Sandstone (T.M.S.) overlies Basement Granite, with the contact-zone at the base of the cliffs.

### *Soils.*

The soils above the cliffs are derived from T.M.S. and are shallow, sandy and well drained. The soils below the cliffs are also shallow, with numerous large areas covered by T.M.S. and Granite scree.

### Climate

No climate data are available from the area, but temperatures are mild (mean annual of about 18°C) with little or no frost. Rainfall is about 1,000 mm per annum and mist occurs, although no measures of frequency or duration are available (personal communication with local residents).

### GENERAL DESCRIPTION

The forest is at the upper limit of Acocks's<sup>1</sup> Coastal Forest and Thornveld veld type and can be briefly described as having four strata, these are:—

(i) A continuous canopy from 11—20 m high with *Protorhus longifolia*, *Drypetes gerrardii*, *Anastrabe integerrima* and *Combretum kraussii* the common species.

(ii) A discontinuous subcanopy layer from 4.5—11 m high. Common species are *Bequaertiodendron natalense*, *Tricalysia capensis*, *Eugenia natalitia*, *Cassipourea gerrardii*, *Ochna arborea* and *Cryptocarya woodii*.

(iii) A discontinuous layer of shrubs from 0.25—3 m high with *Encephalartos villosus*, *Dracaena hookeriana*, *Popowia caffra* and *Uvaria caffra* the most common species.

(iv) A discontinuous layer of herbaceous species with the most widespread being *Cyperus albostrigatus* and *Oplismenus hirtellus*.

Unlike many other forests of Natal which have many lianes and/or epiphytes, the forest at Krantzklouf has few.

### SAMPLING PROCEDURE

#### *Plot size and distribution*

Each sample plot was 40 × 40 m in size and was subdivided into 16, sub-plots of 10 × 10 m. By adding contiguous sub-plots, plot sizes of 20 × 20, 20 × 40 and 40 × 40 m were obtained.

The choice of plot size was based on previous estimates of the density of canopy tree species; the size had to be large enough to include a small number of canopy trees, but not so large that the labour of counting shrubs became prohibitive.

A grid comprising 12 equal-sized squares, approximately two hectares in size, was placed over a greatly enlarged aerial photograph of the forest and one plot was located in each grid-square. Four grid-squares were in a line along the top of the cliffs and eight below. Plots were located by pacing a random distance from the corner of a grid-square, along the cliff top or base, then a further random distance at right angles to the cliff.

No criteria were used to determine the minimum numbers of plots required for effective sampling. The twelve  $40 \times 40$  m plots, covering approximately 10% of the total area of forest, excluding marginal zones, were deemed sufficient.

#### *Vegetation data*

Only woody plants were sampled and these were arbitrarily subdivided into three synusiae:—

- (i) Canopy; defined as all tree species with crowns exposed to full sunlight.
- (ii) Intermediate: defined as all species above 2 m but not contributing to the canopy.
- (iii) Shrub: defined as all species from 0.25—2 m high.

#### *Vegetation parameters*

Absolute density values per  $10 \times 10$  m sub-plot were collected so that for each  $40 \times 40$  m plot a value for absolute density and local frequency was available. Apart from species density four basic environmental factors were noted: the angle of slope, aspect, geology and an estimation (on a scale of four) of the visual quantity of surface boulders.

### ORDINATION

The method of ordination developed by Bray and Curtis<sup>2</sup> was used to analyse the data collected. It is based on a floristic comparison of sampled data and assumes that the floristic composition of a site is an expression of the environment of that site.

The aim of the analysis was to ascertain the optimum plot size, parameter and synusia, or combination of synusiae, for analysing this forest type and to study facets of the ecology of some woody species.

#### *Data ordinated*

The various synusial and plot size combinations ordinated are shown in Table 1. Density values for all five synusial combinations were converted to percentage frequency based on the  $10 \times 10$  m sub-plots. It was thus possible, using various synusial combinations, vegetation parameters and plot sizes, to obtain a total of 26 different ordinations.

When the same species occurred in more than one synusia the values were not summed but kept discrete in synusial combinations 'b' and 'c' (Table 1). Consider a hypothetical example of two plots each containing a common species 'Z'; present once in the canopy and 99 times in the shrub synusiae of one plot and 99 times in the canopy and once in the shrub synusiae of the other. It is not justified to equate the two plots on the bases of 'Z' being present 100 times in each. It is much more meaningful to keep the synusiae discrete and consider the same species, in different synusiae, as entities.

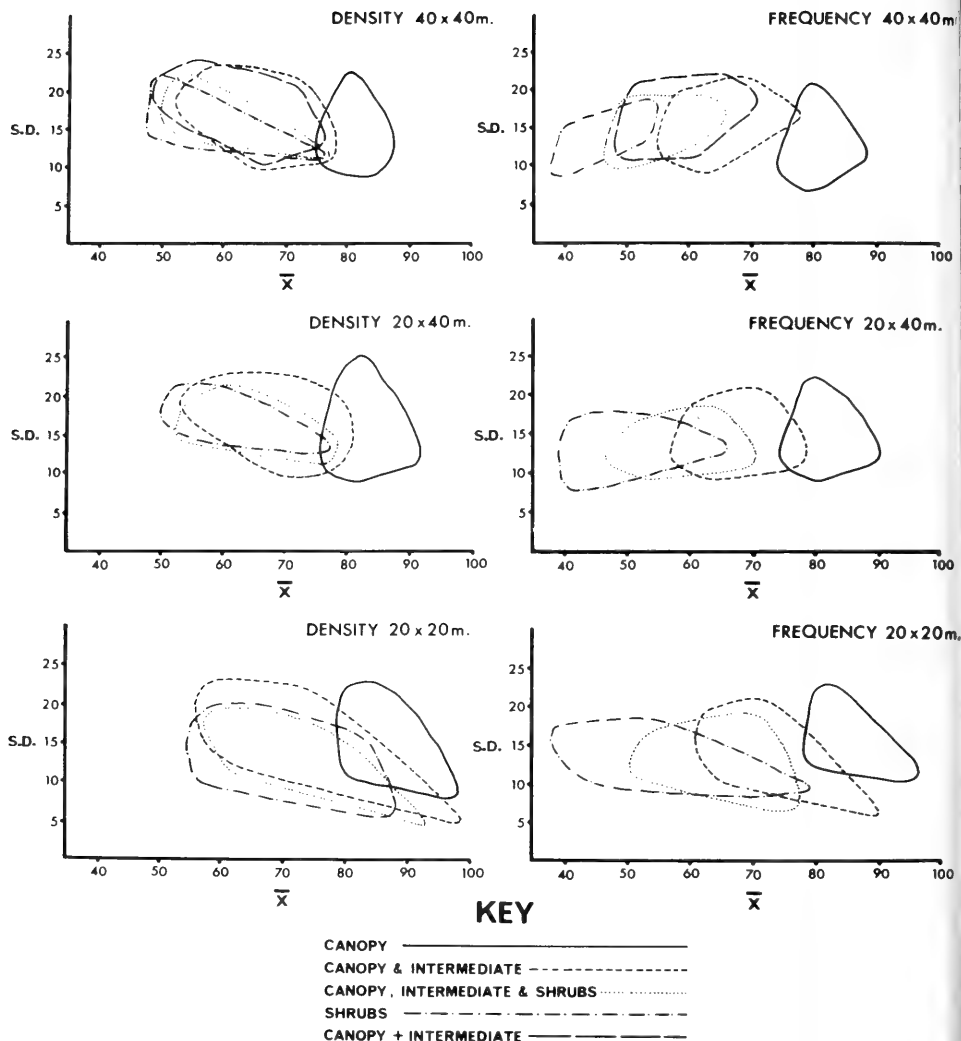


FIGURE 1.  
Distribution of S.D. and  $\bar{x}$  values of the three sizes of plot, two parameters and five combinations of synusiae plotted against each other.



TABLE I. THE POSSIBLE COMBINATION OF SYNUSIAL DATA AND PLOT SIZE.

Synusial Combinations	Plot Size		
	40 × 40 m	20 × 40 m	20 × 20 m
(a) Canopy . . . . .	✓	✓	✓
(b) Canopy intermediate . . . . .	✓	✓	✓
(c) Canopy, intermediate and shrubs	✓	✓	✓
(d) Shrubs . . . . .	✓	✓	✓
(e) Canopy + intermediate . . . . .	✓		

*Results and discussion.*

As such a wide array of data is available from the possible 26 ordinations, some objective method of selecting the best ordination had to be employed. A technique developed by Woods and Moll<sup>3</sup> was used. The mean ( $\bar{x}$ ) of the inverse of the indices of similarity<sup>2</sup> between every plot and every other, was plotted against the standard deviation (S.D.) of the mean (Fig. 1). Data with a high  $\bar{x}$  and S.D. gave the two-dimensional ordination with best use of factor space. By plotting each combination of data it was possible to see which set was the best.

With reference to Fig. 1 the canopy density data for the 20 × 40 m plot size has the highest S.D. and a high  $\bar{x}$ , therefore makes best use of factor space.

As expected when considering broad ecological trends in forest the canopy is the most important synusia, for it is the dominant synusia upon which the entire forest structure and microclimate depend. Furthermore, since canopy species bear the full brunt of external climatic change they will exhibit a more accurate pattern in relation to the macro-environment. It may be argued that the first indicators of an environmental change are the herbaceous plants with a short life cycle, yet forests have taken hundreds or perhaps thousands of years to develop and if forest ecology is to be studied the short periods of climatic change, as long as they are not detrimental to the woody plants, are not important to the general forest ecology.

Comparison of plot size with density and frequency is interesting. The pattern exhibited is similar for each plot size; density is better than frequency showing little difference between the synusial combinations. However, with frequency there are marked differences, canopy is best followed by canopy and intermediate, shrubs, and lastly canopy, intermediate and shrubs. This is to be expected as frequency values greatly reduce the importance of dense local aggregations of species. A final observation, important for future studies, is that there is not a great deal of difference between canopy density and canopy frequency though the former is slightly better.

Two axes, X and Y, were sufficient to account for the floristic variability

of the  $20 \times 40$  m canopy density data and the resulting two dimensional scatter, shown in Fig. 2., has a significant correlation coefficient (between measured inter-plot distances and calculated dissimilarity values) of 0.71.

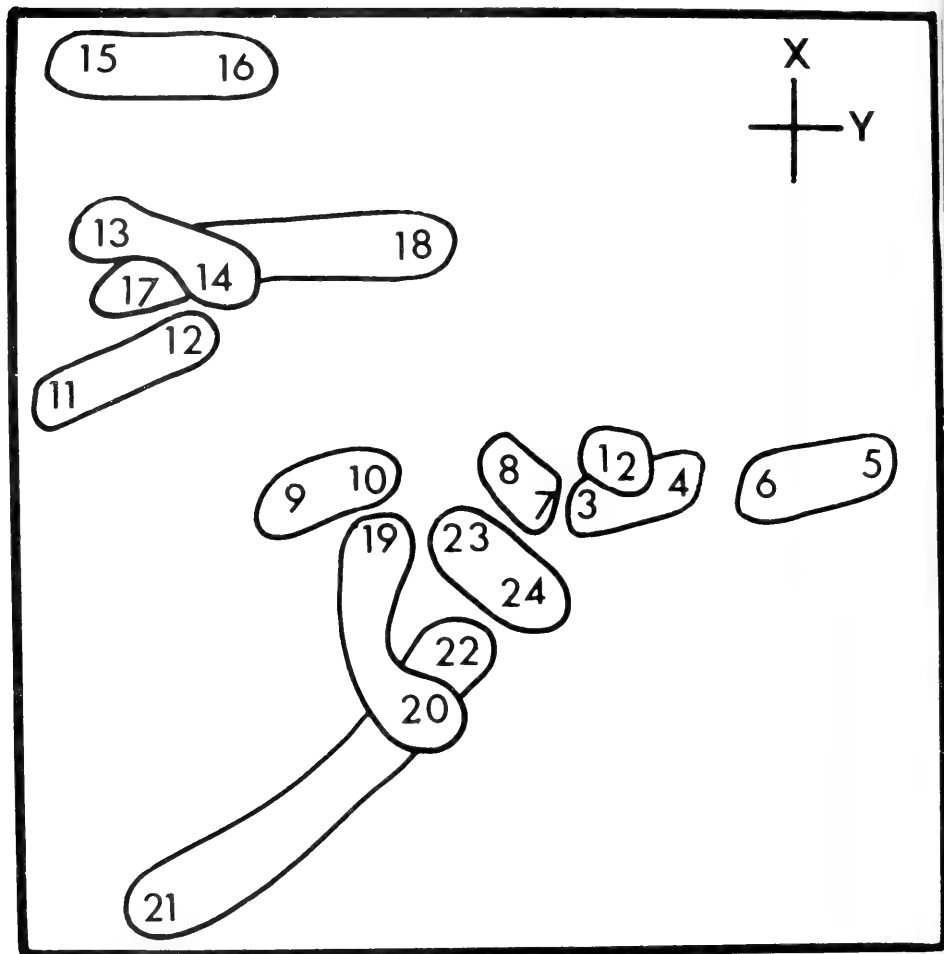


FIGURE 2.  
Ordination of  $20 \times 40$  m canopy density. Contiguous plots are ringed.

The 24 points, representing the  $20 \times 40$  m plots, of the scatter diagram are derived from halving the twelve,  $40 \times 40$  m plots. Contiguous plots have been ringed to give some indication of the homogeneity of the original, larger plot size.

Fig. 3 shows the collected environmental data plotted within the ordination and isolines are used to draw attention to high and/or low ratings in these and subsequent diagrams.

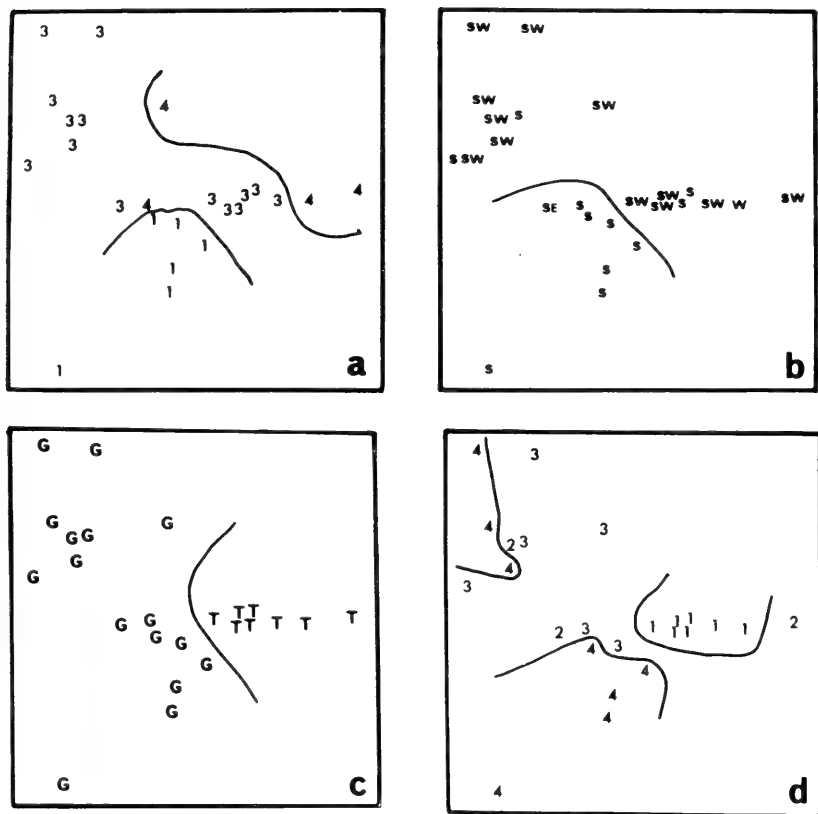


FIGURE 3.

Distribution within the ordination of: (a) angle of slope (1=14°–24°, 2=28°–34° and 3=>35°); (b) aspect (S=south, SE=southeast, SW=southwest and W=west); (c) geology (T=T.M.S. and G=granite); and (d) rocks (minimum to maximum on a scale 1–4).

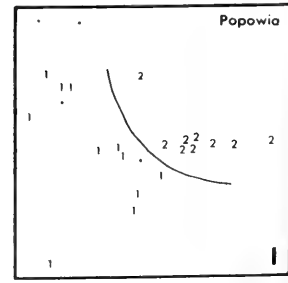
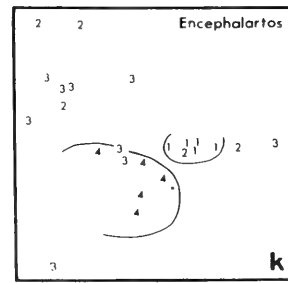
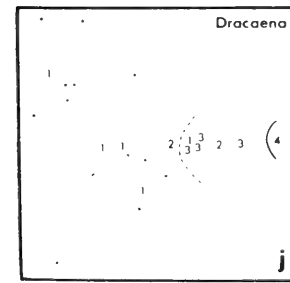
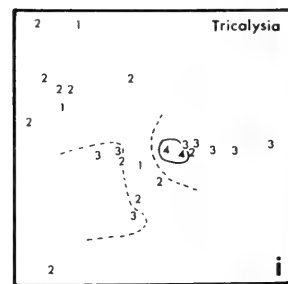
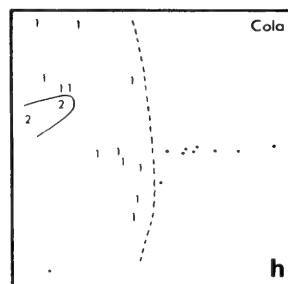
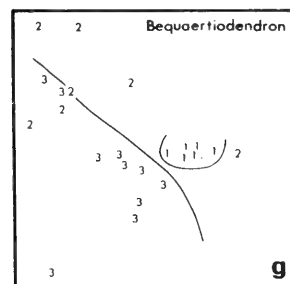
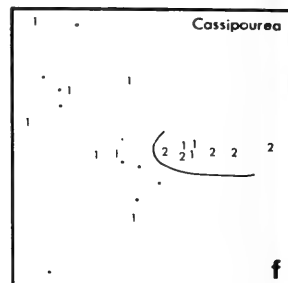
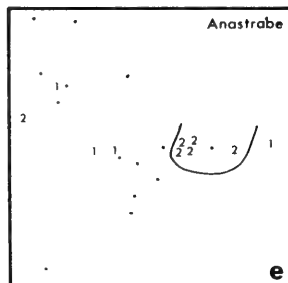
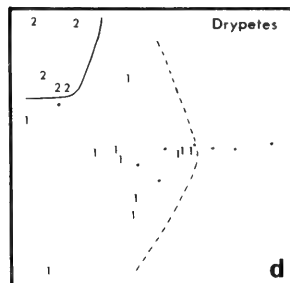
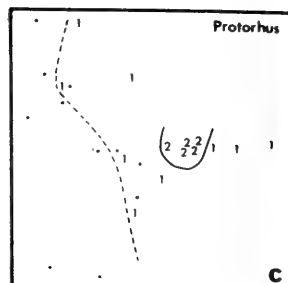
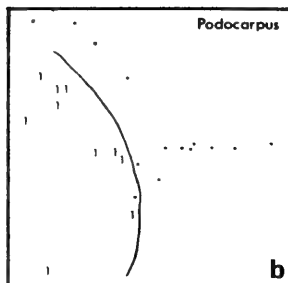
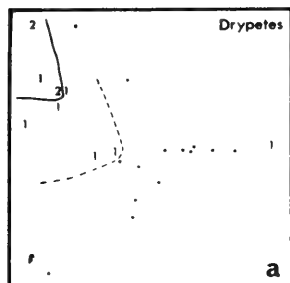


Fig. 4 shows the distribution of selected canopy, intermediate and shrub species within the ordination. The species selected occurred in ten or more plots and show relationships with the environmental factors in Fig. 3.

With reference to Figs. 3 and 4; *Drypetes* (Fig. 4a and d) occurs in the medium steep, southwest-facing plots on granite with much boulder scree, *Podocarpus* (Fig. 4b) is similar in performance to *Drypetes*, while *Protorhus* (Fig. 4c) occurs on the medium steep, south- to southwest-facing plots on T.M.S. with least boulder scree. Similar comparisons can be made with the other species plotted in Fig. 4.

Because of limited space additional species data and the suggested site-succession relationships from Figs. 3 and 4 have been summarized in Fig. 5.

### CONCLUSIONS

The analysis of 26 different combinations of data, collected from 12 restrictedly randomized  $40 \times 40$  m plots, by the Wisconsin<sup>2</sup> ordination procedure was investigated using the method developed by Woods and Moll<sup>3</sup>. Canopy density data for the  $20 \times 40$  m plot size were found to give the best ordination. The various environmental and species density data were plotted within this ordination and the results are summarized in Fig. 5. The plots on T.M.S. above the cliffs were considered seral to those on granite below. Seral species are *Protorhus longifolia*, *Brachylaena uniflora*, *Canthium ventosum*, *Cassipourea gerrardii*, *Cryptocarya woodii*, *Rothmannia globosa*, *Anastrabe integerrima*, *Eugenia natalitia*, *Carissa bispinosa*, *Dracaena hookeriana* and *Popowia caffra*, and grow on the shallow sandy soils with minimum surface boulders. The climax forest was separated into two types, the first with *Drypetes gerrardii* and *Cola natalensis* on the very steep and rocky sites and the second with *Podocarpus latifolius*, *Bequaertiodendron natalense*, *Tabernaemontana ventricosa* and *Encephalartos villosus* on the less rocky and least steep sites. It is also possible that the latter type is the most mesic forest as it is south-facing.

FIGURE 4.

Distribution within the ordination of the density of three canopy species (a to c), six intermediate species (d to i) and three shrub species (j to l); (a) *Drypetes gerrardii* (1=1-4 and 2=7-10); (b) *Podocarpus latifolius* (1=1-3); (c) *Protorhus longifolius* (1=1-6 and 2=8-15); (d) *Drypetes gerrardii* (1=1-5 and 2=10-28); (e) *Anastrabe integerrima* (1=1-2=4-8); (f) *Cassipourea gerrardii* (1=1-7 and 2=20-38); (g) *Bequaertiodendron natalensis* (1=4-12, 2=17-36 and 3=48-85); (h) *Cola natalensis* (1=1-5 and 2=15-26); (i) *Tricalysia capensis* (1=1-5, 2=6-20, 3=21-60 and 4=>61); (j) *Dracaena hookeriana* (1=1-2, 2=8-18, 3=35-75 and 4=339); (k) *Encephalartos villosus* (1=5-10, 2=15-25, 3=30-70 and 4=70); and (l) *Popowia caffra* (1=1-8, 2=40-70).

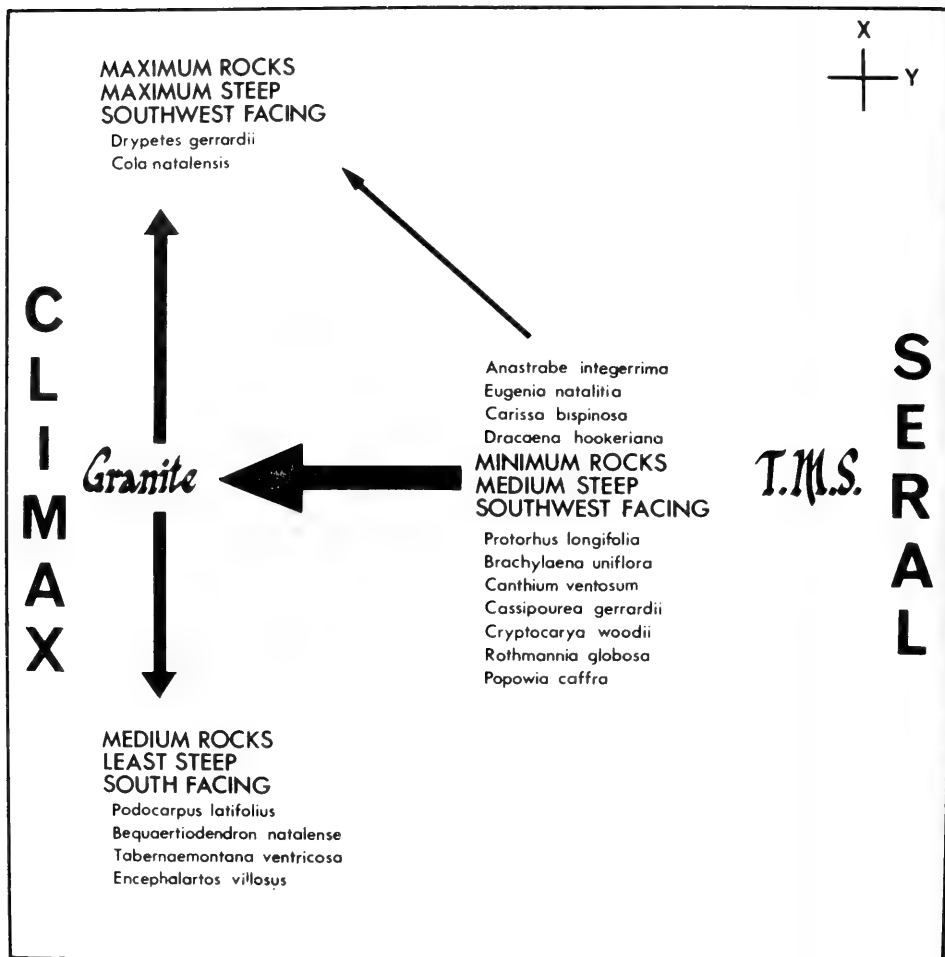


FIGURE 5.  
A diagrammatic representation of suggested environmental gradients and successional trends within the ordination.

#### ACKNOWLEDGEMENTS

I wish to express my thanks to Mr. G. Webb and staff at the Natal University Computer Centre in Durban, the Natal Parks Game and Fish Preservation Board for permission to work in an area under their jurisdiction, and the Chief, Botanical Research Institute, and Secretary, Agriculture Technical Services, for permission to publish these findings.

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# DEFICIENCIES OF MAJOR NUTRIENT ELEMENTS IN *PROTEA CYNAROIDES* LINN., GROWN IN SAND CULTURE.

## II. EFFECT ON GROWTH AND CHEMICAL COMPOSITION

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Republic of South Africa)

### ABSTRACT

The effects were investigated of deficiencies of the major nutrient elements (N, P, K, Ca, Mg, S, and Fe) on the growth and chemical composition of *Protea cynaroides* grown in sand culture.

Only deficiencies in the rooting medium of K, N, and Ca had appreciable effects on growth and a deficiency of iron alone influenced the chemical composition of the plants.

### INTRODUCTION

In a previous paper (van Staden, 1967) mineral deficiency symptoms in *P. cynaroides* were described.

Except for a short report by Schütte (1960) on trace element deficiencies in the Cape vegetation, no information is available on the growth and chemical composition of the South African Proteaceae. Another recent study of mineral nutrition in the Proteaceae is that of Moore and Keraitis (1966), in which was reported deficiency symptoms in *Greyvillea robusta*, in Australia.

In the present paper, the effect of the major nutrient elements on the growth and chemical composition of *P. cynaroides* is described.

### MATERIAL AND METHODS

Plants (three per treatment) of *Protea cynaroides* Linn., were grown in 24 clay pots for 41 weeks in a greenhouse maintained between 8° and 30°C, as previously described (van Staden, 1967). At the end of this time, each plant was carefully removed from the sand and the roots washed with deionised water. Each was then divided into stems and roots (at the cotyledonary node)

and leaves. Stem length was measured from the growing point to the cotyledonary node. Dry weights of stems, leaves and roots were determined after drying at 105°C for 48 hours.

The leaves and stems were analyzed for total nitrogen, potassium, magnesium and iron according to the methods described by Humphries (1956). Calcium was determined by the method of Wolf and Ichisaka (1947) and phosphorus by the method of Jackson (1958). All colorimetric determinations (P, Ca, and Fe) were made with a Model 900·3 Klett-Summerson Photoelectric colorimeter. For the determination of potassium and magnesium a Zeiss PM Q II Flame photometer was employed.

### RESULTS AND DISCUSSION

*Effect on growth:* The effects of deficiencies of the various nutrient elements on the yield of *P. cynaroides* are expressed in Table 1.

The results of this experiment indicate that, with the exception of potassium, calcium and in two instances nitrogen, deficiencies of the major nutrient elements had relatively little effect upon the growth of *P. cynaroides*. Deficiencies of potassium and calcium, however, resulted in a diminution of almost all the aspects of growth measured. A nitrogen deficiency only affected the dry weight yield of leaf and root. The rest of the treatments (P, Mg, S, and Fe) had no significant effects on any characters measured. The deficiencies were obtained within 10 weeks after the plants had previously been grown with complete nutrient solutions (van Staden, 1967). Thus it might be expected that deficiencies of potassium and calcium will have a pronounced effect upon this species in nature, as well as in cultivation. It is further of interest that the results of the deficiencies are similar to those reported in other plants (Wallace, 1961; Lockard and Asomaning, 1964; Nichols, 1965; Moore and Keraitis, 1966). This indicates that *P. cynaroides* is very sensitive and that the slightest

TABLE I  
Effect of major nutrient element deficiencies on the number of leaves, stem length, and dry weight of *Protea cynaroides*.

	Treatment								L.S.D.
	Control	-N	-P	-K	-Ca	-Mg	-S	-Fe	
Number of leaves	118	80	116	59	85	88	99	85	49
Stem length (cm)	23·4	8·0	20·5	7·2	7·1	17·1	16·3	16·9	15·7
Dry weight of leaves (g)	10·7	5·4	8·8	4·2	3·8	9·0	8·5	8·5	5·2
Dry weight of stems and leaves (g)	12·0	6·0	10·1	4·6	4·3	10·0	9·8	9·4	7·1
Dry weight of roots (g)	1·4	0·7	1·1	0·5	0·4	0·9	0·8	0·7	0·7

form of malnutrition will have a marked effect upon its growth.

*Effect on chemical composition:* The effects of mineral deficiencies on the chemical composition of *P. cynaroides* are given in Table 2.

As could be expected, due to the fact that the plants were grown with a complete nutrient solution for 31 weeks, deficiencies of the major nutrient elements had hardly any effect on the chemical composition of *P. cynaroides*. It is, however, of significance that the iron content of the plants decreased significantly with nitrogen, potassium, calcium and iron deficiencies in the rooting medium. With each of these deficiencies severe chlorosis and necrosis of leaves was observed. Wallace and Hewitt (1946) pointed out that deficiencies of potassium, phosphorus or calcium are possible causes of apparent iron deficiency in plants. It would seem as if mineral interrelationships possibly played a role in *P. cynaroides* but this has not yet been substantiated.

TABLE II  
Effect of major nutrient element deficiencies on the chemical composition of  
*Protea cynaroides*.

mg/g dry wt.	Treatment								L.S.D.
	Control	-N	-P	-K	-Ca	-Mg	-S	-Fe	
Phosphorus	2.65	3.14	1.37	6.01	8.93	2.44	4.89	1.75	4.41
Potassium	14.8	14.6	13.6	10.2	13.1	15.4	15.0	13.1	5.8
Calcium	4.16	3.72	2.58	1.62	2.62	2.60	2.69	3.64	1.60
Magnesium	2.86	2.86	3.00	2.83	1.77	2.98	3.97	3.53	2.23
Iron	2.67	1.15	1.56	1.14	0.96	2.08	2.96	0.73	1.42
Nitrogen (%)	1.84	1.61	1.76	1.99	1.85	2.12	2.08	1.65	0.86

#### ACKNOWLEDGEMENTS

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# ELEKTRIESE DROOGPERS VIR HERBARIUM- EKSEMPLEARE

PHILLIP VAN DER MERWE<sup>1</sup> AND P. J. GROBLER<sup>2</sup>

(*Staatsherbarium, Stellenbosch*)

## ABSTRACT

### ELECTRIC DRYING PRESS FOR HERBARIUM SPECIMENS

A new apparatus has been designed to speed up the drying process of herbarium specimens.

Electric blankets are used to heat an ordinary plant press. The result is a drastic shortening of the drying and handling period of herbarium specimens. The changing of drying papers is completely eliminated without any risk of fungous contamination.

The quality of herbarium specimens is also improved by this method.

Verskeie metodes om die droogtyd van herbariumeksemplare te bespoedig is in die verlede toegepas. Onder andere is geventileerde elektriese oonde gebruik maar sonder veel sukses aangesien die verhitting van die kern van die pers onvoldoende is met gevolglike kondensasie van vog in die pers waardeur die droogproses gestrem word.

Die probleem is dus die verhitting van die kern van die plantpers. Die elektriese plantpers is ontwerp om hierdie probleem op te los.

### Konstruksie van elektriese droogpers

Die elektriese plantpers is basies 'n konvensionele plantpers met elektries-verhitte komberse (25 × 40 cm) eweredig versprei tussen die gewone absorberende papierdroogvelle.

'n Termostaat word in die stroombaan geskakel om die gekose werks-temperatuur te beheer.

Aangesien met oop weerstande en klam plante gewerk word, word 'n transformator gebruik om die 220V stroomspanning af te bring na 30V ten einde moontlike elektriese skokke uit te skakel.

---

<sup>1</sup> Tans van die Dept. Landbou-tegniese Dienste, seksie Akkerbou/Weiding, Winter-reënstreek, Stellenbosch.

<sup>2</sup> Tans van die Nasionale Botaniese Tuine van Suid-Afrika, Kirstenbosch.

'n Smeltdraad word in die stroombaan aangebring om oorbelading van die transformator te voorkom.

'n Rooi indikatorlig word gebruik om aan- en af-posisies van die apparaat aan te dui.

Ten einde die ventilasie in die pers nie te strem nie, word die elektriese warmkomberse van seildoek vervaardig. Elke kombers bestaan uit twee stukke seildoek ( $25 \times 40$  cm) wat aanmekaar gestik word om parallelle bane (kanale) 1 cm wyd tussen die twee seildoeke oop te laat waardeur die elementdraad geryg word.

Vir elke kombers word een spiraal 600W/220V elementdraad gebruik. Die spiraal word uitgerek totdat die draad nog net 'n effense kinkel het, voordat dit tussen die seildoeke ingeryg word. Die kinkel in die draad hou die seildoeke verder van mekaar weg en bevorder sodoende deurlugting. Die begin en einde van die elementdraad word vervang met geïsoleerde elektriese drade, elk 30 cm lank.

Tien elektriese kombers (die getal hang af van die stroom wat die transformator kan lewer) word deur die 30 cm geleidrade parallel aan mekaar geskakel en aan die transformator (30V) verbind. Die primêre spoel van die transformator word aan die 220V hoofleiding geskakel.

'n Verstelbare termostaat word op 'n vlekvrystaalplaat van  $25 \times 43$  cm gemonteer, en in die stroombaan geskakel.

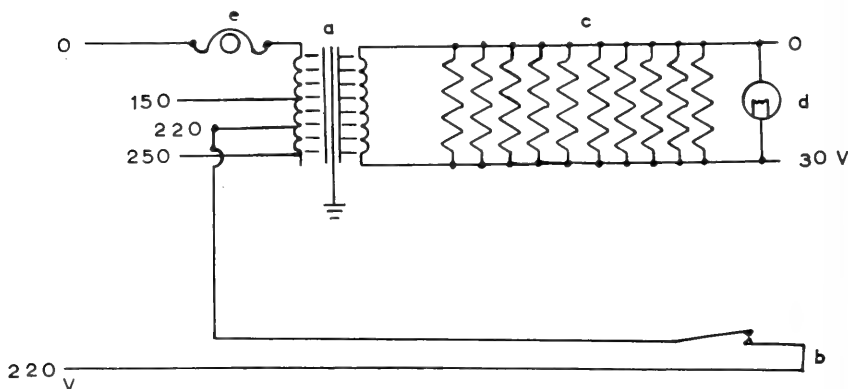
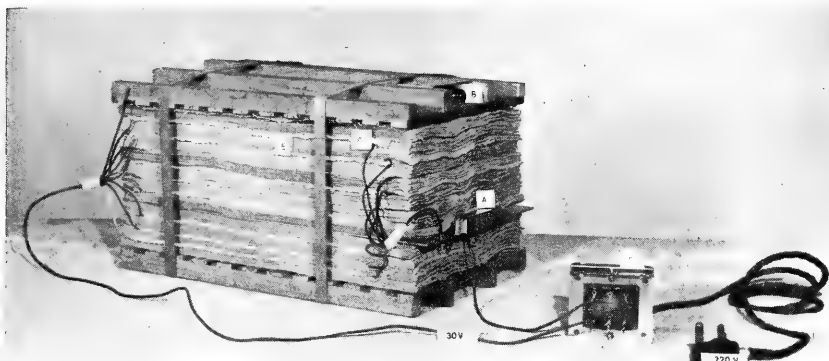


FIG. 1.

Diagram van bedrading van die elektriese pers/*Diagram of wiring of electric press.*  
 a = Transformator/*Transformer*; b = Termostaat/*Thermostat*; c = Weerstand 220V/600W/*220V/600W resistance*; d = Indikatorlig/*Indicator light*; e = Smeltdraad/*Fuse*.



PLAAT I/PLATE I.

Die elektriese plantpers/*The electric plant press.*

A = Termostaat/*Thermostat*; B = Indikatorlig/*Indicator light*; C = Elektriese kombers/*Electric Blanket*; D = Transformator (Primêr 220V/sekondêr 30V)/*Transformer (Primary 220V/secondary 30V)*; E = Droogpapier/*Drying paper*.

Die elektriese komberse word eweredig tussen die droogvelle van 'n konvensionele plantpers geplaas. Die staalplaat met termostaat word tussen komberse 5 en 6 geplaas sodat die termostaat in die middel (en warmste posisie) van die pers is. Die termostaat word op 60°C ingestel.

Die hoeveelheid droogpapier sal die grootte van die pers bepaal.

### Proewe met die elektriese droogpers

Met die elektriese plantpers kan plante op twee maniere gedroog word. Die plante kan in die pers gepak word wanneer die pers koud is of wanneer die pers sy gestelde werktemperatuur bereik het. Hierdie laasgenoemde metode is veral van belang wanneer plante soos die *Erica*-soorte, wat geneig is om hulle blare te verloor, so spoedig moontlik gedroog moet word.

'n Proef is onderneem om die droogspoed van die elektriese plantpers te toets. Op 14/1/1965 is 17 plantsoorte in duplikaat versamel en op 15/1/1965 om 9.00 vm. is die een stel plante in 'n koue elektriese pers gepak. As kontrole was die duplikaatstel plante in 'n gewone plantpers geplaas op 15/1/1965 om 8.00 vm.

### RESULTATE

Die plante in gemelde proef het 23 uur geneem om te droog in die elektriese plantpers en 116 uur in die gewone plantpers.

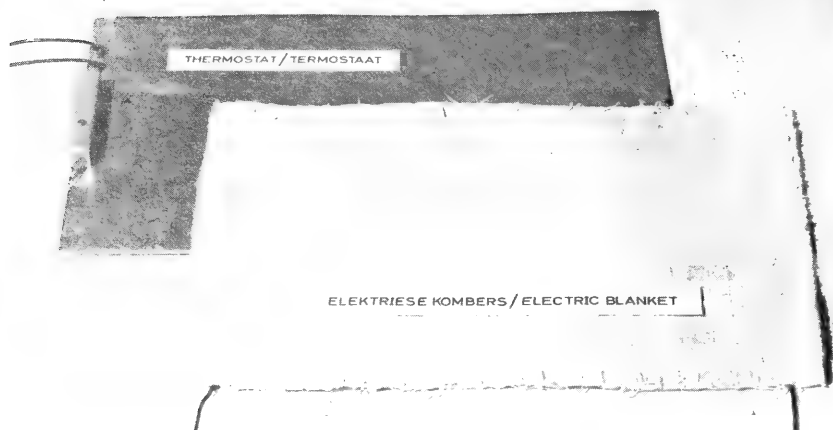
In die geval van die elektriese plantpers het die inpak en uithaal van die plante 20 minute in beslag geneem en geen verwisseling van papier was nodig nie. Die inpak en uithaal het by die gewone plantpers ook 20 minute in beslag geneem plus 'n verdere 60 minute vir die vervanging van die nat papier met droë papier gedurende die droogproses.

Dieselfde 17 soorte wat vir die spoedtoets gebruik is, is beoordeel vir kleur, vorm, voorkoms en moontlike swambeskadiging. Een, twee of drie punte is aan elke eksemplaar toegeken na gelang die kwaliteit daarvan. Die puntetoekenning is onafhanklik van mekaar deur drie persone gedoen op so 'n manier dat vooroordeel uitgeskakel is. Die gewone plantpers se 17 monsters is onderskeidelik 29, 25 en 27 (gem. 27) punte toegeken deur die drie beoordelaars en die elektriese plantpers se 17 monsters is 29, 36 en 35 (gem. 33) punte toegeken.

#### GEVOLGTREKKINGS

Volgens die beoordeling van die 17 eksimplare, lewer die elektriese plantpers net sulke goeie of selfs beter eksimplare (gem. 33 punte teenoor 27) as die gewone plantpers.

Die hoër puntetoekenning is veral daaraan tewyte dat die vinnige droging



PLAAT II/PLATE II.

Elektriese kombers en Termostaat/*Electric blanket and Thermostat.*



tesame met die hitte-effek, mooier platgedrukte eksemplare lewer. Kleur-reaksies was spesiegebonde. Sekere soorte behou hul kleur beter in die elektriese plantpers en ander soorte weer in die gewone plantpers.

Tydbesparing is egter die vernaamste aanspraak van die elektriese plantpers. Die elektriese plantpers het die 17 eksemplare 93 uur gouer gedroog as die gewone plantpers, terwyl die gewone plantpers ook 60 minute meer hanteertyd geverg het. (Die droogpapier in die elektriese pers word nie verwissel nie).

Meer eksemplare en ongunstige weerstoestande sou hierdie verskil in droogtyd na verwagting nog verder beklemtoon het.

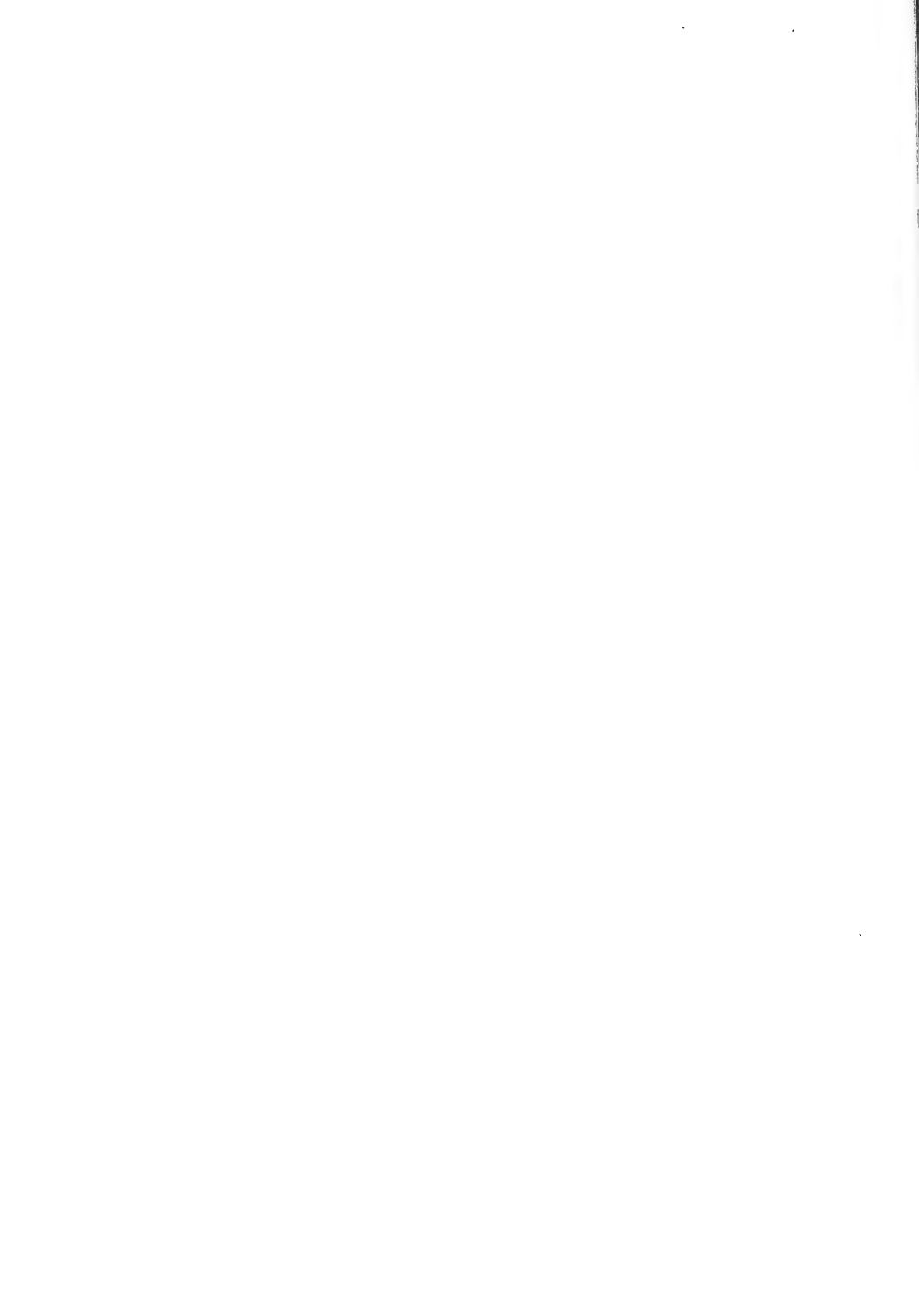
Hierdie besparing van tyd beteken doeltreffender besteding van tyd met gevolglike verhoging in produksie en verlaging in produksiekoste. 'n Vermindering in droogtyd het 'n afname in hanteertyd (en hanteerbeskadiging) en 'n uitskakeling van swambeskadiging tot gevolg. Meer en beter eksemplare kan dus gouer en goedkoper gelever word.

#### OPSOMMING

Deur gebruik te maak van elektriese warmkomberse in 'n konvensionele plantpers, word die droog- en hanteertyd van herbarium-eksemplare drasties ingekort. Die vervanging van droogvelle (papier) in die plantpers word geheel uitgeskakel en geen swambeskadiging kom voor nie.

#### DANKBETUIGING

1. Prof. P. G. Jordaan, Dept. Botanie, Universiteit van Stellenbosch, word bedank vir sy aanmoediging en beskikbaarstelling van materiaal en geriewe.
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# 'n ANATOMIESE EN ONTOGENETIESE STUDIE VAN DIE WORTELS VAN SUID-AFRIKAANSE LILIACEAE:

## I. DIE STRUKTUUR VAN DIE MERISTEMATIESE WORTELPUNT EN DIE OORSPRONG EN DIFFERENSIASIE VAN DIE PRIMÊRE WEEFSELS.\*

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### ABSTRACT

The structure of the apical meristem and the differentiation of the primary tissues in the roots of 11 species of South African Liliaceae were investigated.

On the basis of the developmental relation between the initiating region and the primary tissue regions, only one type of root apex was found, viz. with three tiers of initials. The central cylinder, the cortex and the rootcap have separate initials and the epidermis develops from the same initials as the cortex. This corresponds with one of the three types of root apices described by Schüepp (1926) for the Liliaceae, viz. III Eb.

Apices of all the roots investigated in the present study correspond with the so-called "closed type" of von Guttenberg (1960).

Large metaxylem primordia are among the most recent derivatives of the initials of the procambium. The protoxylem elements, however, mature before those of the metaxylem.

Some species have a many-layered velamen which develops by periclinal divisions of the protoderm.

### INLEIDING

Baie min navorsing is tot op datum gedoen oor die wortelanatomie van Suid-Afrikaanse soorte van die Liliaceae.

Volgens Krause (1930) sluit die Liliaceae twaalf sub-families in. Van hierdie twaalf word sewe in Suid-Afrika verteenwoordig deur inheemse soorte.

Die moderne neiging in die plantanatomie is om ondersoek in te stel na die moontlike taksonomiese waarde van anatomiese kenmerke. In hierdie verband kan verwys word na die huidige navorsing van dr. C. R. Metcalfe aan die Jodrell Laboratorium, Kew. (Vgl. ook Metcalfe & Chalk, 1950). Met die oog hierop is besluit om 'n keuse te maak van Suid-Afrikaanse soorte en om sodoende 'n

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\* Verkorte weergawe van 'n proefskrif goedgekeur vir die graad van Doktor in die Natuurwetenskappe aan die Universiteit van Stellenbosch, September 1965.

begin te maak met 'n vergelykende anatomiese ondersoek van die wortels van hierdie familie.

In die huidige studie is die bou van die wortelpunte en die differensiasie van die primêre weefsels by elf soorte ondersoek.

Uit die beskikbare literatuur kan verwys word na die werk van Schüepp (1926) oor die rangskikking van die inisiale in die apikale meristeem. Na aanleiding van alle beskikbare resultate tot op daardie stadium groepeer hy die wortelpunte van die Liliaceae in drie strukturele patrone wat hy aandui met: III Ca, III Ea en III Eb. (Sien ook bl. 54).

Mullendore (1935) maak 'n studie van die anatomie van die kiemplantjie van *Asparagus officinalis*. Hy verwys o.m. na Treub (1875) se bevindings dat die wortelpunte van die Liliaceae slegs twee duidelike groepe inisiale vertoon. (Treub se werk het ek nie gesien nie).

Mann (1952), soos aangehaal deur Esau (1953), beskryf die apikale meristeem van die wortel van *Allium sativum* en sê dat al die verskillende weefsels uit 'n algemene inisiale streek ontstaan.

Heydel en von Guttenberg (1957) maak 'n vergelykende studie van die ontwikkeling van en die apikale differensiasie in die primêre-, sy- en bywortels by 'n paar soorte van die Liliaceae. Weens die uiteenlopende aard van hulle ontstaan en ontwikkeling, word voorgestel dat hierdie wortels eintlik afsonderlik en nie as 'n eenheid nie, bestudeer moet word.

Von Guttenberg (1960) verwys na die organisasie van die apikale meristeem in die wortels van *Allium giganteum*, *Anthericum ramosum* en *Galtonia candicans*. Hy groepeer hierdie wortelpunte onder sy sg. oop tipe. (Sien ook bl. 54).

#### MATERIAAL EN METODES

Bywortels is gebruik in die ondersoek aangesien die kiemworteltjie by die Liliaceae-soorte vroeg afsterf en die wortelstelsel gevolglik adventief uit die stingel ontwikkel.

Wortels van geïdentifiseerde plante is goedgunstelik verkry van die Nasionale Botaniese Tuine, Kirstenbosch en die Nasionale Herbarium, Pretoria. Eksemplare van sommige van die soorte is gekweek van saad wat verkry is van die Nasionale Botaniese Tuine, Kirstenbosch. Herbariummonsters van hierdie soorte word bewaar in die herbarium van die departement Plantkunde aan die Universiteitskollege Wes-Kaapland. Materiaal verkry van die Nasionale Botaniese Tuine, Kirstenbosch is ook as herbariummonsters daar geliasseer.

FAA (Johansen, 1940) is deurgaans gebruik as fikseermiddel en het bevredigende resultate gelever. Die materiaal is ná fiksering deeglik uitgewas in lopende kraanwater vir ongeveer twee uur. Vir die dehidrasie is die materiaal

agtereenvolgens vir drie tot vier uur in elk van die volgende etielalkohol-oplossings geplaas: 15 %, 30 %, 50 %, 70 % + erythrosien, 80 %, 90 % en 100 %. Erythrosien kleur die materiaal sodat dit beter georiënteer kan word gedurende inbedding en mikrotomering. Dit is veral noodsaaklik by dié wortelpunte waarvan mediane lengtesneë gesny moet word.

Ná dehidrasie is die materiaal geplaas in 100 % etielalkohol-xilol (1:1) vir ongeveer ses uur en daarna in suiwer xilol vir 'n verdere agt uur. Klein stukkies paraffienwas (smeltpunt 52°C) is bygevoeg totdat die oplossing versadig is. Daarop is die xilol in 'n oond (60°C) verdamp, en is die materiaal ingebed.

Lengtesneë is 10  $\mu$  dik gesny en dwarsneë 16 tot 20  $\mu$ . Safranien in kombinasie met vaste groen is deurgaans as kleurmiddel gebruik en het bevredigende resultate gelever.

Mikrofoto's is geneem met 'n Wild-plaatkamera (6.4 cm  $\times$  8.9 cm).

#### DIÉ KEUSE VAN TERME IN DIE HUIDIGE ONDERSOEK

##### 1. Die apikale- en promeristeem

Volgens Haberlandt (1914) en Esau (1953) word die begrip, apikale meristeem, so toegepas dat dit beide die meristematiese inisiale en hulle onmiddellike derivate in die wortelpunt insluit. Dit word gedoen omdat die inisiale moeilik te onderskei is van hulle onmiddellike derivate en ook nie altyd die meeste delingsfigure vertoon nie. Die inisiale kan dus eintlik net aan hulle besondere posisie in die apikale meristeem uitgeken word.

Die apikale meristeem word in hierdie ondersoek as ooreenstemmend beskou met die promeristeem, maar sluit nie in die gedeeltelik bepaalde derivate van die promeristeem nie, nl. die drie primêre meristeme, te wete die protoderm, die grondmeristeem en die prokambium.

Die term promeristeem, soos hier gebruik, stem dus nie ooreen met die sienswyse van Clowes (1961) nie. Hy gebruik dit slegs vir die inisiale selle.

In hierdie ondersoek word deurgaans verwys na die inisiale lae wat in die apikale meristeem voorkom.

##### 2. Protoderm, prokambium en grondmeristeem

Hierdie terme word verkies vir die meristematiese weefsels wat ontwikkel uit die apikale inisiale (vgl. Haberlandt, 1914) bo die terme van Hanstein (1868) vir die drie histogene, te wete dermatogeen, plerom en peribleem. Lg. terme is nie gebruik nie, omdat dié drie histogene in die wortels van talryke Angiospermae nie onderskei kan word nie. Die dermatogeen en die peribleem mag

bv. soms gemeenskaplike inisiale hê. Dit is in sulke gevalle dat von Guttenberg (1960) praat van 'n sekondêre dermatogeen, m.a.w. een wat uit die buitenste peribleemlaag differensieer. Die sekondêre dermatogeen stem dus ooreen met die protoderm van die huidige ondersoek. Die term kaliptrogeen, vir die vierde histogeen (Janczewski, 1874), word wel in die huidige ondersoek gebruik.

Die terme protoderm, prokambium, grondmeristeen en kaliptrogeen dien doeltreffend vir die beskrywing van die patroon van differensiasie in wortels en korreleer met die eenvoudige en toepaslike klassifikasie van volwasse weefsels in epidermis, stele of sentrale silinder en wortelmussie.

### 3. Epidermis

Dit word verkies bo rhizodermis (von Guttenberg, 1960) omdat dit tog die buitenste laag selle van die wortel uitmaak in dié streek waar die wortelmussie nie meer aanwesig is nie.

### 4. T-delings (fig. 1)

Dit is 'n term wat geskep is deur Schüepp (1917), soos aangehaal deur Clowes (1961), in sy Körper-Kappe-teorie vir die patrone van seldelings in wortelpunte. 'n Toename in sydelingse selrye naby die wortelpunt is 'n uitstaande kenmerk van wortels. Hierdie rye straal uit vanaf 'n streek naby die inisiale en een ry selle mag verdeel in twee. Waar dit gebeur word die aansluiting veroorsaak deur 'n sel wat anti- en periklinaal verdeel. Sodanige opeenvolgende delings

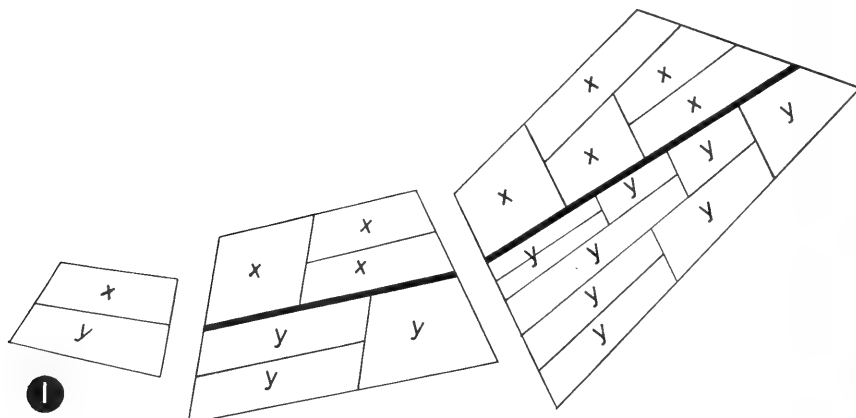


FIG. 1.

'n Skematiese voorstelling van die selverdelingsvlakke in die wortelpunt volgens Schüepp (1917), vir sy Körper-Kappe-teorie: x, Körper; y, Kappe. Let op die T-delings in die Kappe en die omgekeerde T-delings in die Körper.

is deur Schüepp T-delings genoem. Hy het ook waargeneem dat die T omgekeerd (t.o.v. die mussie) staan in die selle van die sentrale gedeelte van die wortel en regop in die selle van die buitenste gedeelte van die wortel. In die huidige ondersoek word dus soms ook verwys na omgekeerde T-delings.

#### 5. **Trichoblast**

In sommige plante vertoon die wortelepidermis 'n morfologiese differensiasie in haarvormende selle (trichoblaste) en in selle wat nie hare vorm nie.

#### 6. **Afkortings**

D.S. — dwarssnee

M.L.S. — mediane lengtesnee

R.L.S. — radiale lengtesnee

#### ONDERSOEK

##### A. *Die apikale meristeem en die histologie soos gesien in mediane lengtesneë*

Wortelpunte van elf soorte, verteenwoordigend van vier sub-families, is ondersoek en vergelyk met die oog op vasstelling van moontlike ooreenkomste en verskille in die struktuur en ontwikkeling van die apikale meristeem.

Behalwe vir die sywortelpunte by *Bulbinella robusta*, is die ondersoekte wortelpunte in die derde stadium van ontwikkeling van von Guttenberg (1960), m.a.w. hulle is wortelpunte wat reeds uit die moederweefsel uitgetree het.

Die wortelpunte van die volgende soorte is ondersoek:

##### **SUB-FAMILIE: ASPHODELOIDEAE**

###### **TRIBUS: *Asphodeleae***

*Bulbinella robusta* Kunth

*Chlorophytum capense* (L.) Voss

###### **TRIBUS: *Aloineae***

*Kniphofia ensifolia* Baker

*Gasteria pillansii* Kensit

*Aloe arborescens* Mill. en *A. ciliaris* Haw.

##### **SUB-FAMILIE: ALLIOIDEAE**

###### **TRIBUS: *Agapantheae***

*Agapanthus praecox* Willd. en *A. pendulus* (L.Bol.) Leighton

##### **SUB-FAMILIE: SCILLOIDEAE**

*Albuca aurea* Jacq.

*Scilla natalensis* Planch.

##### **SUB-FAMILIE: DRACAENOIDEAE**

###### **TRIBUS: *Dracaeneae***

*Sansevieria longiflora* Sims

1. *Bulbinella robusta* (fig. 2—3)

Daar is drie lae inisiale in die apikale meristeem, nl. een vir die prokambiumsilinder, een vir die grondmeristeem en protoderm en een vir die kaliptrogeen. Die selle is relatief groot met groot kerne en 'n digte protoplasma. Besonder duidelik is die omgekeerde T-delings in die grondmeristeem waardeur die skors basipetaal in dikte toeneem (fig. 3). Dit is duidelik dat die laag selle wat grens aan die buitekant van die prokambiumsilinder, m.a.w. die toekomstige endodermis, nie as 'n kambium funksioneer soos voorgestel deur Williams (1947) nie. Von Guttenberg (1960) sê ook dat die endodermis nie as 'n kambium funksioneer nie en dat die skorslae se selle radiaal voorkom as gevolg van omgekeerde T-delings vanaf die apikale meristeem. As gevolg van herhaalde transversale delings in die kaliptrogeen, ontstaan 'n kolumella in die wortelmussie. Aan die kante van die wortelmussie kom T-delings voor waardeur die mussie ook sydelings gedurig nuwe selrye vorm (fig. 3). Transversale

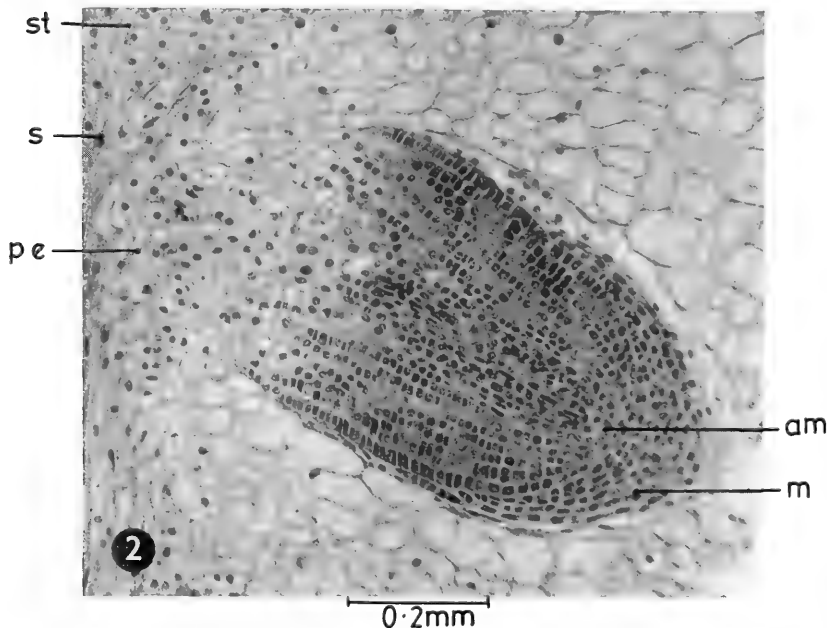


FIG. 2.

*Bulbinella robusta*. M.L.S. van 'n jong syworteltjie: am, apikale meristeem; m, wortelmussie; pe, perisikel waarin seldelings plaasgevind het; s, sentrale silinder van die moederwortel; st, stingelbasis.



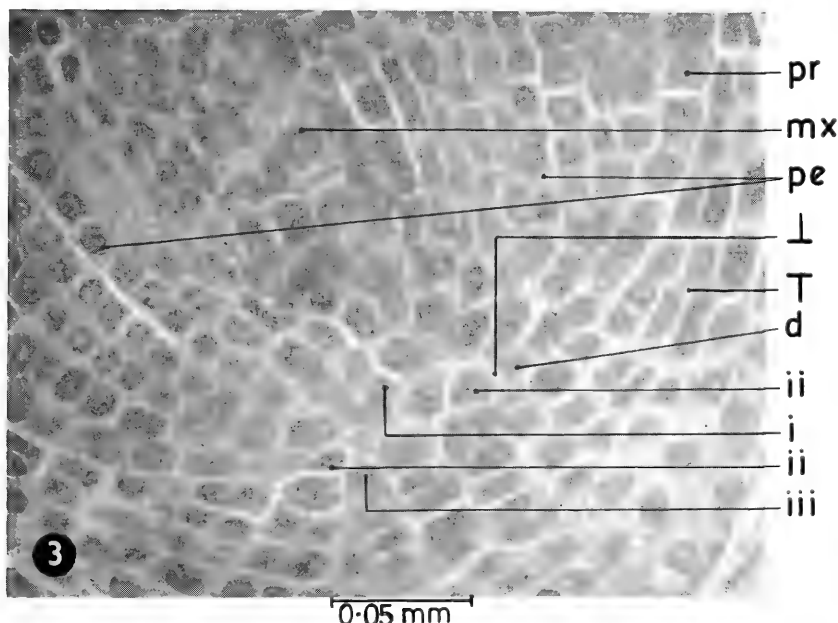


FIG. 3.

*Bulbinella robusta*. M.L.S. van die apikale meristeem van die jong syworteltjie in fig. 2: d, differensiasie van die protoderm uit die inisiaal by ii; i, inisiale van die prokambium; ii, inisiale van die grondmeristeem en protoderm; iii, inisiale van die wortelmussie; mx, metaxileemprimordium; pe, jong perisikel; pr, protoderm; T, t-deling; T, omgekeerde t-deling.

delings van die kaliptrogeen na die kante van die wortelmussie is duidelik sigbaar tot sowat 0.2 mm vanaf die middellyn van die apikale meristeem; m.a.w. die kaliptrogeen strek baie wyd oor die apikale meristeem. Die protoplasma in die mussieselle is reeds baie nader aan die apikale meristeem minder dig as dié van selle in die grondmeristeem en prokambiumsilinder, en vakuole begin vroeër vorm in die mussieselle. Die wortelmussie strek ver terug oor die wortelpunt.

Die differensiasie van die protoderm en grondmeristeem uit 'n gemeenskaplike inisiaal kan goed waargeneem word in figuur 3. Geen trichoblaste kon

onderskei word in die jong epidermis nie.

Meristematiese selle wat eventueel tot metaxileemvate differensieer, is naby aan die apikale meristeem sigbaar. Hierdie selle is wyd en vakuoleer op 'n vroeë stadium (fig. 3).

## 2. *Chlorophytum capense*

Hier kon ook dieselfde drie lae inisiale in die apikale meristeem onderskei word as by *Bulbinella robusta*.

Proksimaal van die apikale meristeem is dit die selle van die sentrale silinder wat, ongeag of hulle xileem-, murg- of parenchiemselle gaan word, eerste vakuoleer, gevolg deur die selle van die middelskors. Die epidermisselle word radiaal verleng en besit, tot op 'n laat stadium, 'n digte protoplasma. Geen trichoblaste kon onderskei word nie. 'n Duidelike eksodermislaag differensieer reeds vroeg uit die vlak grondmeristeem. 'n Radiale rangskikking van skorselle kon nie in die lengtesnee waargeneem word nie. Die prokambiumsilinder kon duidelik onderskei word deurdat die jong perisikelselle relatief klein is, 'n digte protoplasma besit en gevolglik 'n opvallende laag vorm. In die wortelmussie kon 'n kolumella waargeneem word.

Seldingsfigure kon waargeneem word in die middel van die apikale meristeem (vgl. Clowes, 1961—„quiescent centre”).

## 3. *Kniphofia ensifolia*

Drie lae inisiale kom voor in die apikale meristeem en die drie primêre weefselstreke, nl. die sentrale silinder, skors en epidermis en die wortelmussie is duidelik waarneembaar onder swak vergroting, weens verskille in die selgroottes en die kleuringsintensiteit van hul selinhoude. Die verskillende stadia waarop selle van die drie primêre weefselstreke vakuoleer ten opsigte van hul ligging teenoor die apikale meristeem, was opvallend.

As gevolg van die vroeë stadium waarop seldings in alle vlakke in die kaliptrogeen intree, is 'n kolumella nie duidelik te onderskei in die wortelmussie nie. Die wortelmussie strek ver terug oor die wortelpunt—tot sowat 2 mm vanaf die apikale meristeem.

Die differensiasie van metaxileemprimordia naby die apikale meristeem kon waargeneem word.

## 4. *Gasteria pillansii* (fig. 4—6)

Die apikale meristeem besit drie lae inisiale en elke laag bestaan in die lengtesnee uit 'n transversale ry selle, min in aantal (vgl. ook *Bulbinella robusta*).

Die wortelmussie is betreklik klein en beslaan sowat twaalf sellae vanaf sy punt tot by die kaliptrogeeninisiale, en strek sowat 1 mm agtertoe oor die wortelpunt. Die selle van die wortelmussie vakuoleer naby aan die apikale meristeem.

Die protoderm differensieer vroeg tot selle met 'n digte protoplasma. Deur aanhoudende antiklinale verdelings word hierdie selle aansienlik afgeplat (fig.

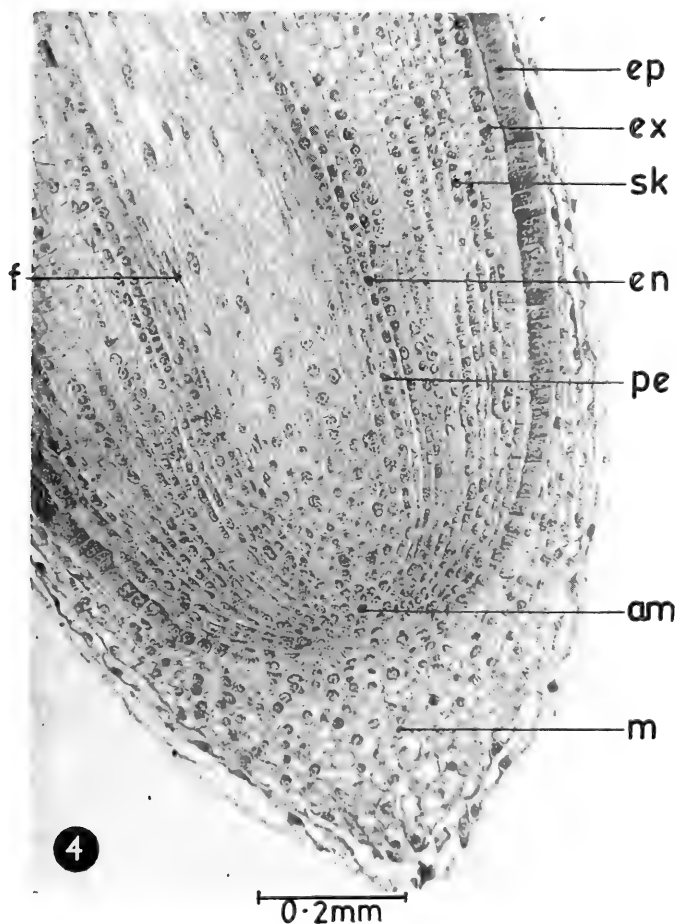


FIG. 4.  
*Gasteria pillansii*. M.L.S. van die wortelpunt: am, apikale meristoom;  
en, endodermis; ep, epidermis; ex, eksodermis; m, wortelmussie; f,  
sifvat; pe, jong perisikel; sk, jong skors.

4, 6). Dit is dus moeilik om op hierdie stadium trichoblaste, indien enige aanwesig is, uit te ken.

'n Eksodermis differensieer naby aan die apikale meristeem uit die grondmeristeem. Links in figuur 5, kan gesien word hoe die eksodermis uit die buitenste sel van 'n omgekeerde T-vormige selgroepie differensieer.

Sowat 0.05 mm vanaf die apikale meristeem is die perisikellaag reeds duidelik sigbaar (fig. 4). Dit word gevolg deur die endodermis op sowat 0.1 mm. Die perisikelselle is korter as die endodermis- en die ander skorselle, en kan dus taamlik maklik van die endodermis onderskei word.

Die middelskorselle vakuoleer sowat 0.4 mm vanaf die apikale meristeem, terwyl die selle van die sentrale silinder baie vroeër vakuoleer en die aantal seldelings hier opvallend minder is as in die teenoorstaande skorsgedeelte.

Metaxileemprimordia is waargeneem naby aan die apikale meristeem (fig. 5).

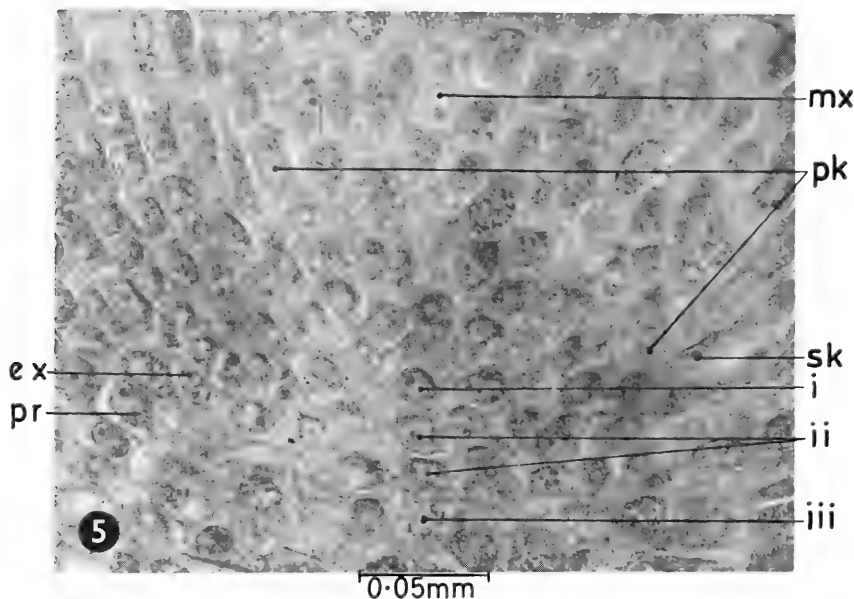


FIG. 5.

*Gasteria pillansii*. M.L.S. van die apikale meristeem; ex, toekomstige eksodermis; mx, toekomstige metaxileemsel; pk, prokambium; pr, protoderm; sk, toekomstige skors; i, inisiale van die prokambium; ii, dogterselle van die inisiale laag van die grondmeristeem; iii, inisiale van die wortelmussie.

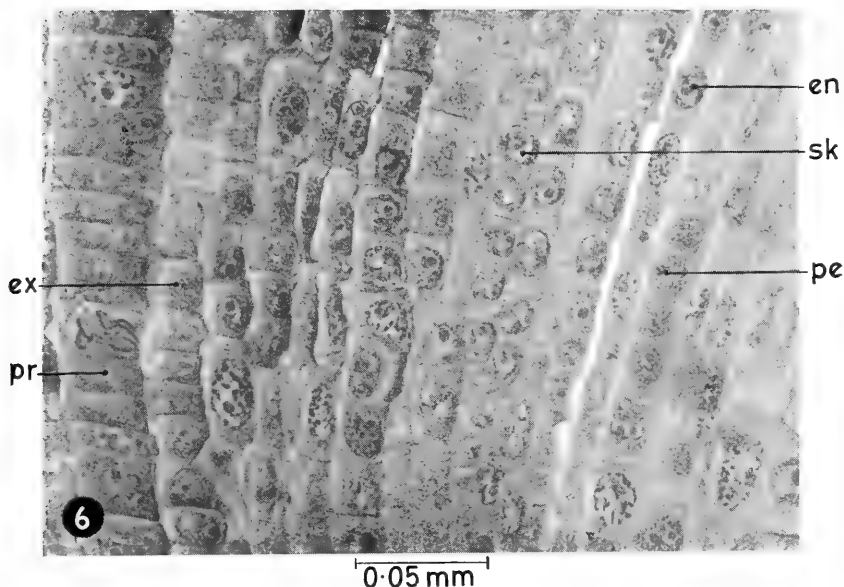


FIG. 6.

*Gasteria pillansii*. R.L.S. van die buitenste gedeelte van die wortel 0.3 mm vanaf die apikale meristeem: en, jong endodermis; ex, jong eksodermis; pe, jong perisikel; pr, protoderm; sk, toekomstige skors. Let op die talryke delingstadia wat nog voorkom in die protoderm en in die jong skors.

##### 5. *Aloe arborescens* en *A. ciliaris*

Ook hier besit die apikale meristeem drie lae inisiale. Die wortelpunte is besonder breed en die selle taamlik klein by altwee soorte.

By *A. arborescens* kon die drie primêre weefselstreke, nl. die sentrale silinder, die skors en epidermis en die wortelmussie goed waargeneem word.

Die kaliptrogeen strek oor 'n wye vlak weerskante van die apikale meristeem. In die wortelmussie was die kolumella, by beide soorte, nie baie opvallend nie as gevolg van die verdeling van die kaliptrogeenselle in baie verskillende vlakke naby aan die apikale meristeem. Die wortelmussie strek ver terug oor die wortelpunt (sowat 1.5 mm).

Sowat 0.2 mm vanaf die apikale meristeem is die protoderm duidelik uitkenbaar as 'n afsonderlike laag eenderse selle en spesiale haarvormende selle kon nie onderskei word nie. Die differensiasie van 'n eksodermis, wat bestaan uit groot en klein selle, kon waargeneem word naby aan die apikale meristeem.

In die grondmeristeem is die voorkoms van omgekeerde T-delings algemeen, met die gevolg dat die skors basipetaal baie toeneem in dikte. Die skors-selle vakuoleer eers later—ná die selle van die sentrale silinder.

Die stele word op 'n vroeë stadium afgebaken deur 'n duidelike perisikkellaag, waarvan die selle kleiner en die protoplasma baie digter is as die aangrensende stele-selle. Die meeste ander selle van die stele begin vakuoleer en verleng feitlik teenaan die apikale meristeem.

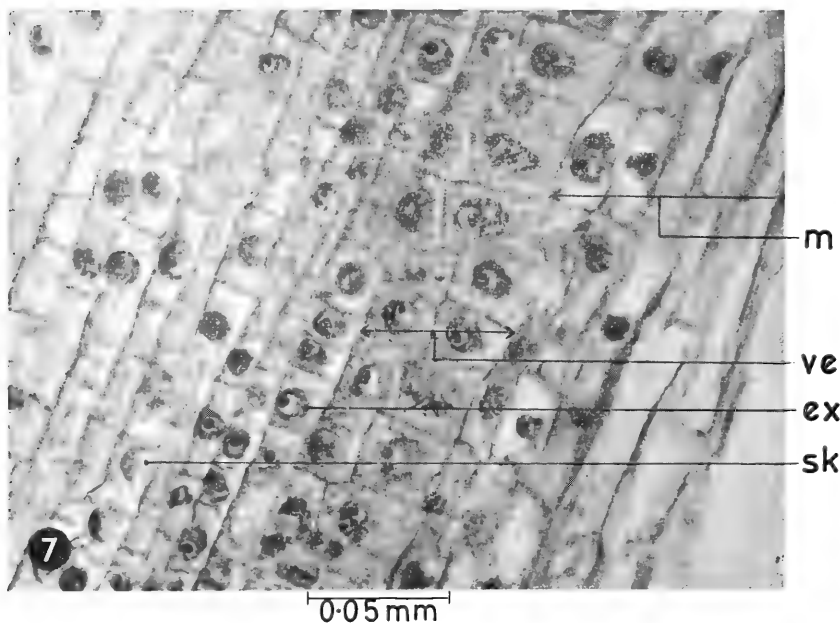


FIG. 7.

*Agapanthus praecox*. R.L.S. van die buitenste sellae van die wortel 0.3 mm vanaf die apikale meristeem; ex, eksodermis; m, wortelmussie; sk, toekomstige skors; ve, protoderm verdeel periklinaal om die velamen te vorm. Let daarop dat die twee sellae van die velamen reeds op hierdie jong stadium nie oral radiaal gerangskik lê nie.

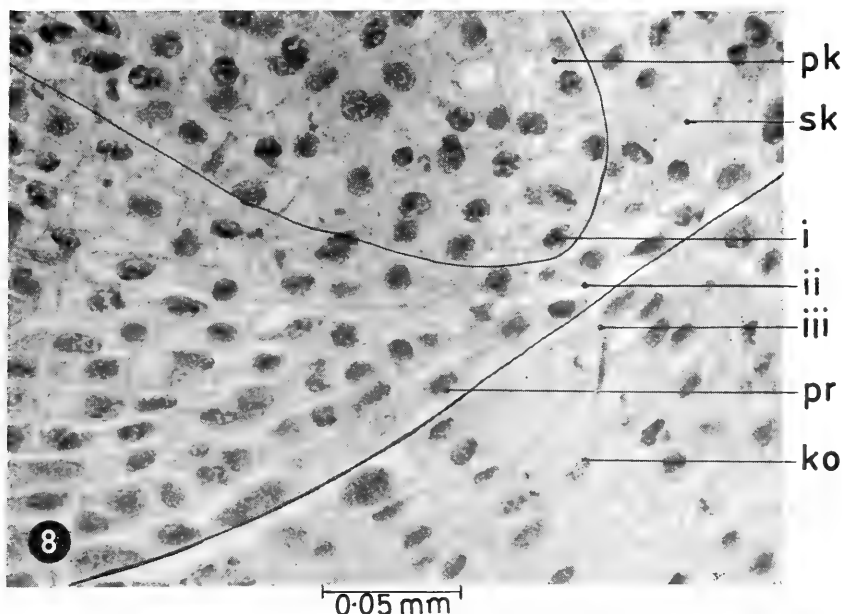


FIG. 8.

*Agapanthus pendulus*. M.L.S. van die apikale meristeem: ko, kolumella; pk, prokambium; pr, protoderm; sk, toekomstige skors; i, inisiale van die prokambium; ii, inisiale van die grondmeristeem en protoderm; iii, inisiale van die wortelmussie.

#### 6. *Agapanthus praecox* (fig. 7) en *A. pendulus* (fig. 8)

Soos by *Aloe arborescens* en *A. ciliaris* is die wortelpunte van die ondersoekte *Agapanthus*-soorte relatief breed en die selle klein.

Die apikale meristeem bestaan uit drie lae inisiale. Die groep wat oorsprong gee aan die prokambiumsilinder is nie so duidelik te onderskei as dié vir die grondmeristeem en protoderm en dié vir die kaliptrogeen nie.

A.g.v. transversale verdelings in die kaliptrogeen, direk teenaan die apikale meristeem, word 'n prominente kolumella gevorm, veral by *A. pendulus* (fig. 8). Die kaliptrogeen vertoon sodanige verdelings oor 'n wye vlak. Dit verklaar die sydelings uitstralende selrye aan die kante van die wortelmussie. Lg. is baie groot en strek ver terug oor die wortelpunt.

Die protodermselle by *A. praecox* begin sowat 0.3 mm vanaf die apikale meristeem periklinaal te verdeel, ten einde 'n velamen van drie tot vyf lae te vorm (fig. 7). Die radiale rangskikking van die velamenselle word versteur deurdat die selle in sy buitenste laag méér vergroot en ook antiklinaal verdeel (fig. 7). Direk aan die binnekant van die velamen differensieer die eksodermis as die buitenste laag selle van die skors. By *A. pendulus* (fig. 8) kan die skors en die protoderm duidelik tot dieselfde sellag in die apikale meristeem teruggevoer word.

Dit is opvallend hoe gou meeste derivate van die apikale meristeem, hetsy wortelmussie, grondmeristeem of sentrale silinder, vakuoleer. Geen radiale rangskikking van die skorsselle kon in die lengtesneë waargeneem word nie.

#### 7. *Albuca aurea*

Die apikale meristeem bestaan ook uit drie lae inisiale.

In die wortelmussie kon die kolumella duidelik waargeneem word.

In hierdie wortelpunt was die inisiale laag vir die grondmeristeem opvallend. Die skors en die protoderm kon duidelik tot hierdie een sellag teruggevolg word. Die protodermselle is afgeplat en byna palissadevormig. Omgekeerde T-delings kon waargeneem word in die grondmeristeem naby aan die apikale meristeem.

Die differensiasie van metaxilemprimordia, naby aan die apikale meristeem, is waargeneem. Dit is die selle wat eerste vakuoleer.

#### 8. *Scilla natalensis* (fig. 9)

Drie lae inisiale word onderskei in die apikale meristeem, nl. een vir die prokambiumsilinder, een vir die grondmeristeem en die protoderm en een vir die kaliptrogeen.

'n Kolumella kon nie duidelik in die wortelmussie onderskei word nie. Alhoewel die wortelmussie relatief klein is, strek dit sowat 1.4 mm terug oor die wortelpunt.

Die protoderm en die toekomstige perisikel kon naby aan die apikale meristeem onderskei word.

'n Duidelike eksodermislaag, bestaande uit afwisselende groot selle en kleiner deurlaatselle, differensieer sowat 0.6 mm vanaf die apikale meristeem (fig. 9). Dit is die middelskorsselle wat eerste vakuoleer en parenchimaties vertoon.

Sentraal, in die prokambiumsilinder, vergroot sommige selle aansienlik alhoewel delings nog daar mag voorkom. Die vergrotende selle is waarskynlik toekomstige metaxilemelemente.

In teenstelling met die *Agapanthus*-soorte, vakuoleer die selle van die skors en die sentrale silinder eers baie later. In *S. natalensis* is dit opvallend dat hierdie



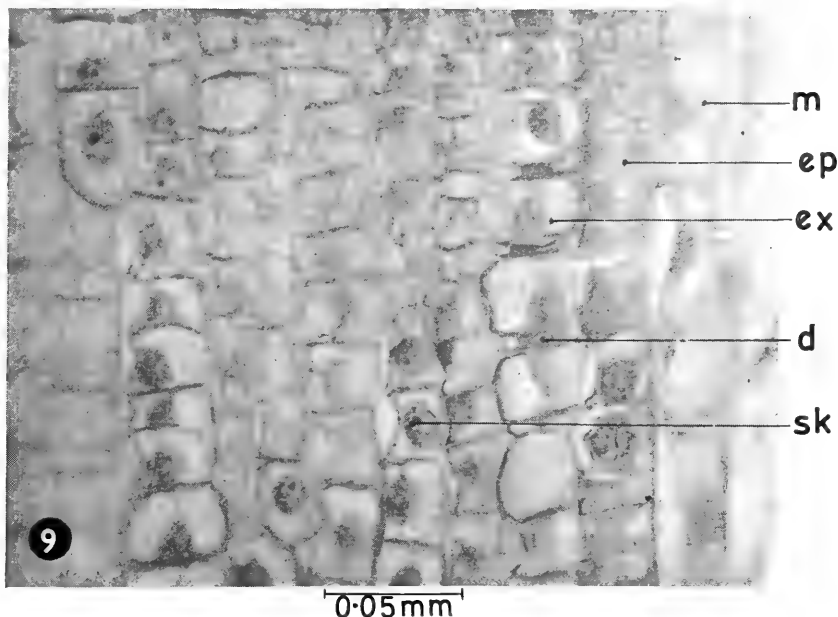


FIG. 9.

*Scilla natalensis*. R.L.S. van die buitenste gedeelte van die wortel 0.6 mm vanaf die apikale meristeem: d, klein deurlaatsel in die eksodermis; ep, epidermis; ex, eksodermis; m, wortelmussie; sk, jong skors.

selle eers op 'n gevorderde stadium van ontwikkeling in lengte toeneem.

#### 9. *Sansevieria longiflora*

Ook in hierdie spesies word drie lae inisiale in die apikale meristeem onderskei.

Die wortelmussie besit nie 'n opvallende kolumella nie. Transversale delings in die kaliptrogeen vind egter oor 'n wye vlak plaas. Die selle aan die kante van die mussie is baie groter en die wande effens verkurk.

Die protoderm vorm 'n onderskeidende laag naby aan die apikale meristeem en vertoon 'n besondere meristematiese aktiwiteit, veral in plekke waar die mussie beskadig is. Die selle vergroot aansienlik en is palissadevormig, soos by

*Gasteria pillansii* (fig. 6).

Die eksodermis is reeds vroeg te onderskei en die kleinere deurlaatselle is opvallend. In die skorsgedeelte is dit die middelskorsselle wat eerste vakuoleer.

Die perisikel word uitgeken aan die selle wat kleiner is, 'n digter protoplasma besit en gevolglik dieper kleur as die aangrensende stele-selle.

Die ontstaan van vakuole en die gelyktydige verlenging van die selle om toekomstige xileemelemente in die sentrale silinder te vorm, begin naby aan die apikale meristeem.

#### SAMEVATTING EN BESPREKING

Net een strukturele patroon vir die rangskikking van die inisiale in die apikale meristeem is in die huidige ondersoek vasgestel, nl. drie lae inisiale—een laag vir die prokambium, een laag vir die grondmeristeem en protoderm en een laag vir die wortelmussie. Al die wortelpunte het dus 'n afsonderlike kaliptrogeen.

Oor die algemeen kon die afsonderlike inisiale lae in die apikale meristeem van breë wortelpunte (bv. *Aloe arborescens* en *A. ciliaris*), nie so duidelik onderskei word soos in die dunner wortelpunte van die ondersoekte soorte nie. Die selle in die apikale meristeem van 'n breë wortelpunt is ook relatief kleiner as in ander wortelpunte.

Soms is dit waargeneem dat 'n groepie selle, sentraalgeleë in die apikale meristeem, nie so baie seldelingsfigure as die omliggende selle vertoon nie. Of hierdie groepie selle ooreenstem met Clowes (1961) se „quiescent centre” of met von Guttenberg (1960) se sentrale selle, is nie duidelik nie.

Die vlakke, waarop die primêre weefsels differensieer, hang af van die grootte van die wortelpunte en die tempo waarteen hulle groei. Wye wortels het gewoonlik 'n langer apikale meristeem as dun wortels (vgl. Clowes, 1961, p. 172).

#### *Wortelmussie:*

Die selwande tussen die kaliptrogeeninisiale en die apikale meristeem is sylmerig en vorm gevolglik 'n taamlik duidelike skeidingslaag. In baie gevalle verdeel die sentrale kaliptrogeenselle herhaaldelik transversaal sodat 'n duidelike kolumella gevorm word. By sommige soorte strek die kaliptrogeen wyd oor die apikale meristeem en dit verklaar die sydelings uitstralende selrye aan die kante van die wortelmussie. Lg. strek in meeste gevalle ver terug oor die wortelpunt. Die selle van die wortelmussie vakuoleer naby aan die apikale meristeem en is parenchimaties.

#### *Protoderm:*

Die protoderm differensieer as 'n duidelike laag naby aan die apikale meristeem. Die protoderm en die grondmeristeem het gemeenskaplike inisiale. Die jong epidermisselle wat hoër op uit die protoderm differensieer is groot, vereers

radiaal verleng en palissadevormig en besit 'n digte protoplasma. Geen trichoblaste kon waargeneem word nie. Die velamen, waar aanwesig, ontwikkel deur periklinale verdelings van die protodermiselle naby aan die apikale meristeem. Die protoderm kan as die epidermis beskou word op dié stadium waar die selle verleng het en daar duidelike vakuolering intree.

*Grondmeristeem:*

Die eksodermis, as buitelaag van die skors, differensieer later as die protoderm en in vier van die spesies is die ontwikkeling van kleiner deurlaatselle waargeneem (vgl. *Scilla natalensis*, fig. 9). By twee van die spesies is die eksodermis meer as een sellaaq breed.

Die skors neem basipetaal toe in breedte as gevolg van verspreide omgekeerde T-delings en nie deur periklinale verdelings van die toekomstige endodermiselle nie. Die selle van die middelskors vakuoleer eerste en hulle is die selle wat gouste ophou om te verdeel en later van die grootste selle in die wortel vorm. Vakuolering versprei geleidelik vanaf die middelskors na buite in die rigting van die epidermis en na binne in die rigting van die stele. In lengtesneë is dit soms moeilik om die jong endodermis as 'n opvallende sellaaq uit te ken, omdat die kenmerkende wandmodifikasies eers op 'n later stadium verskyn (sowat 3 mm vanaf die apikale meristeem).

*Prokambiumsilinder:*

Die grens van die jong stele word in meeste lengtesneë naby aan die apikale meristeem uitgeken aan die longitudinale laag prokambiumselle (die toekomstige perisikkellaag). Hierdie selle is meestal klein, besit 'n digte selinhoud en verdeel slegs transversaal. Proksimaal van die apikale meristeem is dit die selle van die middelste gedeelte van die stele wat eerste vakuoleer en in baie gevalle differensieer as metaxileemprimordia. Hierdie toekomstige xileemvate is breed en opvallend gevakuoleer. Differensiasie van die floëem- en die protoxileemelemente naby aan die apikale meristeem kon nie waargeneem word nie.

*'n Vergelyking van die huidige bevindings in verband met die organisasie van die apikale meristeem met dié van Schüep, von Guttenberg en Clowes*

Dit is bekend dat die inisiale in die apikale meristeem van wortelpunte van die Angiospermae in een of meer opeenvolgende horisontale lae kan voorkom. Hierdie wortelpunte kan dus ingedeel word in sg. tipes op grond van die verhouding tussen die bou van die inisiale streek en die ontwikkeling van die primêre weefselstreke.

Schüep (1926, p. 72—74) groepeer, na aanleiding van alle beskikbare resultate tot op daardie stadium, die wortelpunte van die Liliaceae in drie tipes

(fig. 10), wat hy soos volg aandui:

- III Ca: Drie lae inisiale, nl. een elk vir die plerom, die peribleem en die dermatogeen. Die mussie neem sy oorsprong uit die dermatogeen.
- III Ea: Twee lae inisiale, nl. een vir die plerom en een vir die peribleem, dermatogeen en mussie saam.
- III Eb: Drie lae inisiale, nl. een vir die plerom, een vir die peribleem en dermatogeen en een vir die mussie.

Die resultate van die huidige ondersoek stem slegs met een van sy tipes ooreen, nl. met III Eb.

Von Guttenberg (1960) verwys na die organisasie van die apikale meristeem in die wortels van *Allium giganteum*, *Anthericum ramosum* en *Galtonia candicans*. Hy groepeer hierdie wortelpunte onder sy sg. oop tipe. Hy sê verder dat die promeristeem eintlik uit 'n sentrale sel of sel paar bestaan. Hierdie sel(le) gee oorsprong aan die verbindingsselle wat later weer oorsprong gee aan die drie

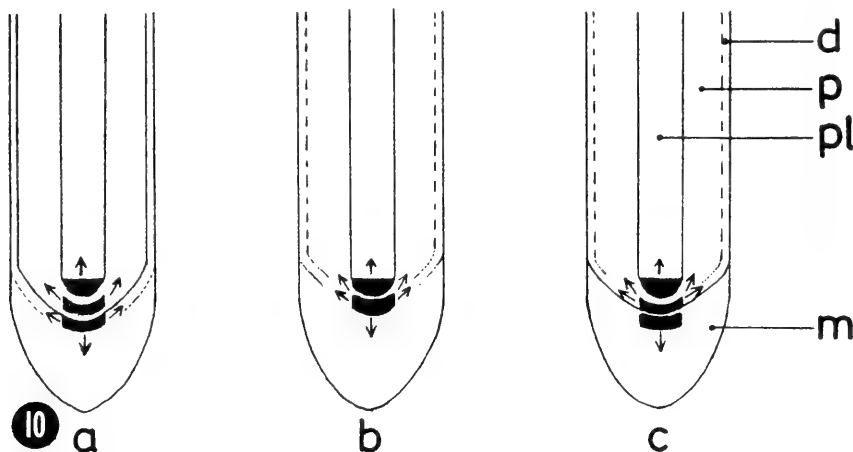


FIG. 10.

'n Skematiese voorstelling van Schüepf (1926) se drie strukturele patrone vir die apikale meristeem in die wortels van die Liliaceae:

- a. III Ca: Drie groepe inisiale—een vir die plerom, een vir die peribleem en een vir die dermatogeen. Die mussie neem sy oorsprong uit die dermatogeen.
- b. III Ea: Twee groepe inisiale—een vir die plerom en een vir die peribleem, dermatogeen en mussie saam.
- c. III Eb: Drie groepe inisiale—een vir die plerom, een vir die peribleem en dermatogeen en een vir die mussie.

d, dermatogeen; m, mussie; p, peribleem; pl, plerom.

histogene. Die sentrale selle is geleë tussen die plerom en die mussie. Hy beskryf drie stadia van ontwikkeling by kiem-, sy- en bywortels, nl.

i. Die volwasse embrio besit 'n geslote wortelaanleg en al die histogene lê teenmekaar—duidelik afgebaken en selfstandig. Dit is ook die geval by die ontwikkeling van die sy- en bywortels in die moederorgaan, m.a.w. voor hul uittreding.

ii. Drie apikale inisiaalsentra ontwikkel wat vir die verdere ontwikkeling van die plerom, peribleem en dermatogeen verantwoordelik is. Hierdie stadium word ook bereik voor uittreding.

iii. Gedurende die derde stadium ontwikkel die apikale meristeem verder, m.a.w. nou begin die eintlike lengteontwikkeling van die wortel. Dit geskied ná uittreding. Dit is ook die stadium waarop wortels kan oorgaan van die geslote na die oop tipe, bv. by *Allium giganteum* (von Guttenberg, 1960, p. 67). In die huidige ondersoek is egter vasgestel dat al die ondersoekte soorte tot sy geslote tipe behoort.

*'n Kort verduideliking van die Oop- en Geslote tipes van wortelpunte by Monokotiele* (von Guttenberg, 1960, p. 100—101)  
*Die Oop tipe:*

Aan die einde van stadium (ii), soos hierbo beskryf, begin die selle van die verbindingsweefsel („Periblemabschluss”) ook periklinaal te verdeel, met die gevolg dat van die derivate die mussie binnedring. Sodoende ontstaan 'n oop verbinding tussen die mussie en die peribleem. Van hierdie derivate kan selfs die plerom binnedring.

*Die Geslote tipe:*

Hier bly al die histogene teenmekaar, duidelik afgebaken en selfstandig, selfs ná uittreding, m.a.w. soos in sy stadium (ii) hierbo.

Von Guttenberg (1960) stel dit ook dat die wortels van die Liliaceae 'n afsonderlike kaliptrogeen besit.

Die resultate in die huidige ondersoek werp geen verdere lig op Clowes (1961) se idee i.v.m. die „quiescent centre” nie. Geen proewe is uitgevoer i.v.m. die sintese van RNS (ribonukleïensuur) en DNS (desoksiribonukleïensuur) nie.

Dit wil voorkom of daar op die oomblik nog geen duidelikheid bestaan oor die „quiescent centre” van Clowes (1961) en die sentrale selle van von Guttenberg (1960) nie. Clowes stem nie saam met von Guttenberg nie, en omgekeerd. Hulle idees is nie ondersoek in die huidige studie nie. Daar is deurgaans net verwys na die lae van inisiale in die apikale meristeem.

**B. Histogenese soos gesien in dwarsneë (fig. 11—13).**

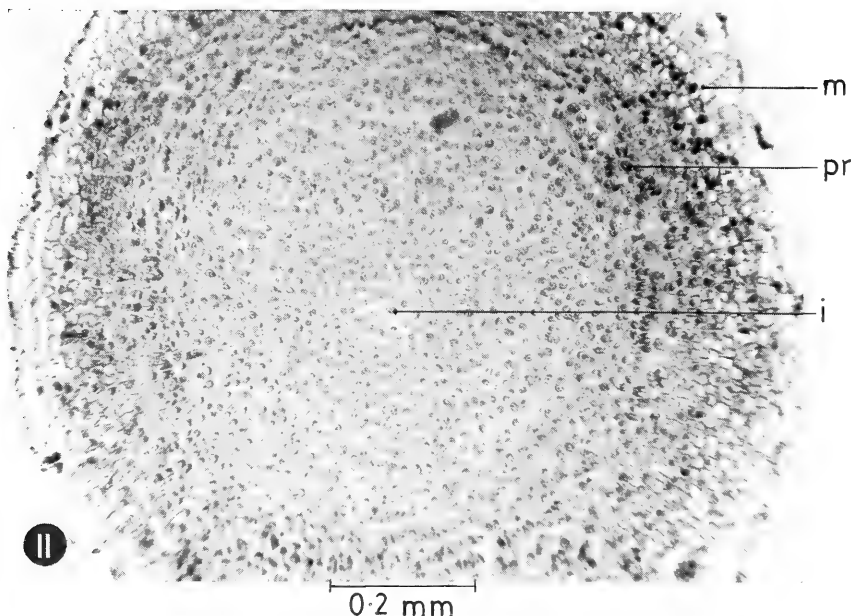


FIG. 11.

*Kniphofia ensifolia*. D.S. van die wortelpunt bokant die vlak van die inisiale streek: i, derivate van die inisiale streek; m, wortelmussie; pr, protoderm.

In dwarsnee is die basiese patroon van die differensiasie en verdere ontwikkeling van die primêre weefsels min of meer eenders by die ondersoekte soorte.

Daar word gevolglik in hierdie ondersoek net verwys na *Kniphofia ensifolia*, *Sansevieria longiflora* en *Scilla natalensis*.

#### ONDERSOEK EN BESPREKING

In die dwarsnee (fig. 11), gesny net bokant die vlak van die inisiale streek, is die enigste selle wat klaar gevakuoleer het dié van die buitenste paar lae van die wortelmussie. Die ander selle, nl. dié van die binneste paar lae van die wortelmussie, die protoderm en die grondweefsel, besit nog 'n digte protoplasma. 'n Groepie selle in die middel van die snee is ligter gekleur omdat hulle protoplasma minder dig is. Hierdie selle is waarskynlik onmiddellike derivate van die prokambiuminisiale.

Die protoderm kan reeds plek-plek onderskei word as 'n afsonderlike sellag. Die selle besit 'n digte protoplasma en is taamlik donker gekleur.

Sowat 0.1—0.2 mm bokant die apikale meristeem begin die epidermis te differensieer uit die protoderm. Die selle is effens gevakuoleer, taamlik groot en radiaal afgeplat as gevolg van antiklinale verdelings. In sommige gevalle is die selwande tussen die protoderm en die wortelmussie slymerig en kan die twee streke taamlik maklik onderskei word.

Trichoblaste kon nêrens waargeneem word as selle wat struktureel, of op een of ander manier, verskil van die ander selle van hierdie laag nie. Wortelhare ontwikkel eers sowat 1.3—1.4 mm bokant die apikale meristeem waar die

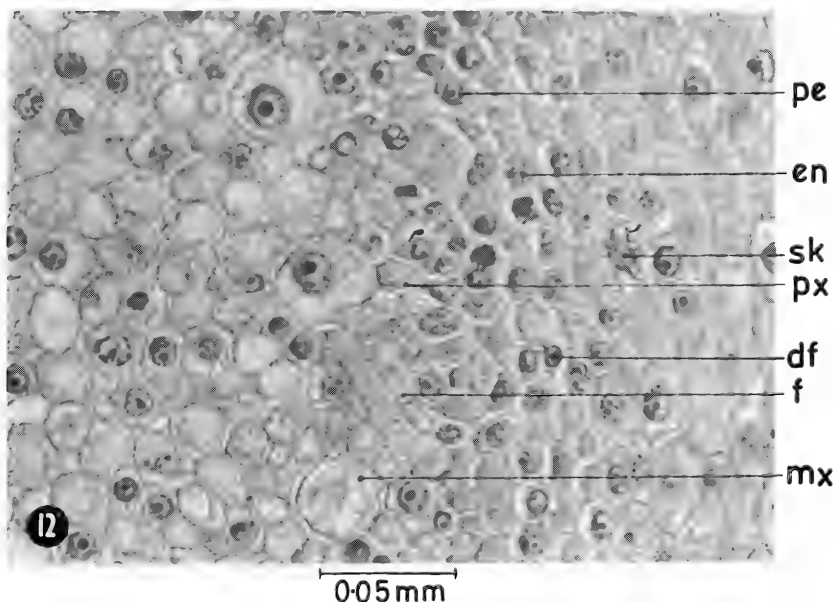


FIG. 12.

*Kniphofia ensifolia*. D.S. van 'n gedeelte van die sentrale silinder en die binneskors; df, periklinale verdeling van 'n jong ongedifferensieerde endodermis; en, endodermis; f, toekomstige sifvat; mx, metaxileemprimordium; pe, perisikel; px, protoxileemprimordium; sk, jong skorsel met 'n delingsfiguur.

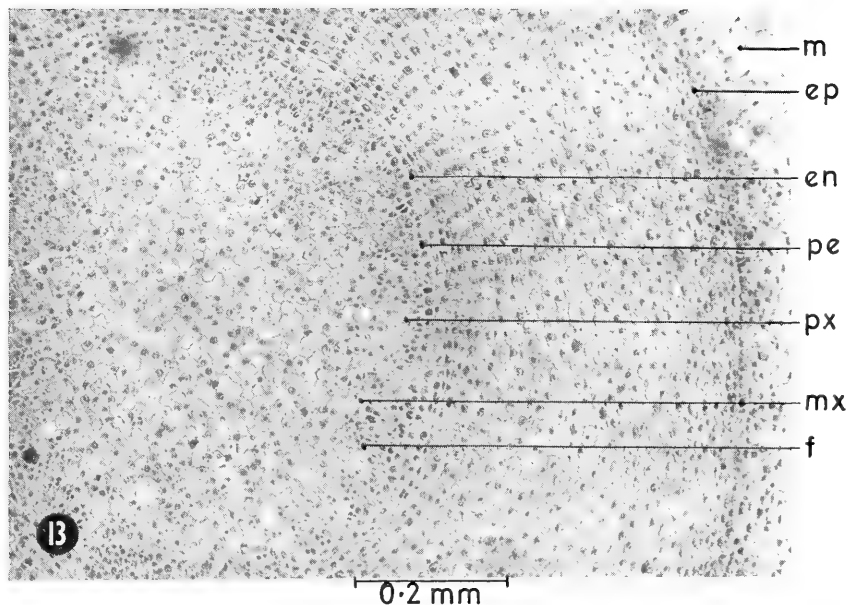


FIG. 13.

*Sansevieria longiflora*. D.S. van die wortelpunt sowat 0.1 mm bokant die apikale meristeem; en, endodermis; ep, epidermis; f, floëem; m, wortelmussie; mx, metaxileemprimordium; pe, perisikel; px, protokileemprimordium. Let op die radiale rangskikking van die selle van die binneskors.

wortelmussie afwesig is. Geen vaste patroon vir die ontwikkeling van die wortelhare is waargeneem nie.

Deur verspreide periklinale verdelings (ook genoem omgekeerde T-delings) van die selle in die grondmeristeem, neem die skors basipetaal toe in dikte. Naby die stele is die selle kleiner, besit 'n digter protoplasma en is min of meer radiaal gerangskik (fig. 13). Die radiale rangskikking kon ook soms waargeneem word in die buiteskors. Dit wou voorkom of die differensiasie van die skors sentripetaal is vanaf die middelskors na die stele en sentrifugaal na die epidermis. Die middelskors selle is groter as die ander skors selle, vakuoleer gouer en intersellulêre ruimtes kom vroeër voor. Aan die buitekant differensieer 'n eksodermis as deel van die skors. Kleiner deurlaatselle in die eksodermis kon nie waargeneem word nie. Dit kon wel waargeneem word in 'n lengtesnee by



*Scilla natalensis* (fig. 9), waar die deurlaatselle as plat selletjies onderskei kon word tussen die ander eksodermiselle; m.a.w. die deurlaatselle ondergaan nie soveel lengtestrekking as die ander eksodermiselle nie, maar almal het dieselfde breedte.

Die endodermis word aanvanklik net uitgeken as die laag selle van die skors wat grens teenaan die stele. Hulle verskil ook van die perisikelselle deurdat hulle in dwarsnee meer baksteenvormig is as die meer onreëlmatige perisikelselle. By *Kniphofia ensifolia* (fig. 12) verdeel 'n jong nog ongedifferensieerde endodermis sel periklinaal om 'n sel tot die skorsparenchiem by te voeg.

Die perisikel, as afsonderlike sellag, word reeds duidelik sowat 0.02—0.05 mm vanaf die apikale meristeem (fig. 12). Vakuole is afwesig of baie klein en die selinhoud is donker gekleur. Net bokant die apikale meristeem (fig. 11) is dit die selle van die sentrale gedeelte van die stele wat eerste vakuoleer. Vakuolering sprei hierna sentrifugaal uit na die protoxileempole. Gevolglik word stroke selle, sonder vakuole, tussen die arms van die xileemgroepe gelaat. Dit is die toekomstige floëemgroepe waarin selverdeling langer aanhou as in die murg- en xileemdele.

Die protofloëem differensieer in die buitewyke van die stele, binne en teenaan die perisikellaag (fig. 12). Die eerste sifvat word begrens deur klein selletjies en lyk soms soos 'n harskanaal. Sommige van die klein selletjies is waarskynlik begeleidende selle en die ander is floëemparenchiem.

By die xileem is dit die toekomstige metaxileemvate wat vroeg reeds begin differensieer deur verbreding, terwyl die kern en die sitoplasma vereers nog aanwesig bly (vgl. Esau, 1953, p. 490). Die metaxileemvate verbreed aansienlik en begin terselfdertyd vakuoleer. Aan die buitekant van die metaxileemvate begin die protoxileemelemente eers later te verbreed en te vakuoleer, maar soos duidelik blyk uit sneë van byna volwasse wortels, is hulle voor die metaxileemvate klaar gedifferensieer.

Die toekomstige xileem- en floëemelemente lê gebed in grondweefsel waarvan die sentrale gedeelte differensieer as toekomstige murg.

#### OPSOMMING

1. Die inisiale in die apikale meristeem kom in drie lae voor—een laag vir die prokambium, een laag vir die grondmeristeem en die protoderm en een laag vir die wortelmussie.
2. Wortelpunte van die huidig ondersoekte soorte behoort tot die sg. geslote tipe van von Guttenberg (1960).

3. Die velamen by *Bulbinella robusta*, *Agapanthus praecox* en *A. pendulus*, ontwikkel deur periklinale verdelings van die protodermsele naby aan die apikale meristeem.
4. Die eksodermis is ontogeneties verwant aan die skors.
5. Primordia van die grootste metaxileemelemente word uitgeken tussen die jongste derivate van die prokambiuminisiale.
6. Geen trichoblaste kon waargeneem word nie.

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**AN ACCOUNT OF THE PLANT ECOLOGY  
OF THE HAWAAN FOREST, NATAL†**

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**ABSTRACT**

The location, physiography and climate of the Hawaan Forest, Natal, are given. The general ecology of the forest margin and climax forest, with special reference to structure, composition and density of trees and shrubs from 50 random sample sites, and gap succession is outlined. A preliminary checklist of angiosperms occurring in Hawaan is appended.

**INTRODUCTION**

The Hawaan forest is a relic patch of climax dune forest occurring in Acocks's (1953) Coastal Tropical Forest Type. It is situated 10 miles north of Durban at the intersection of co-ordinates 29°42' south and 31°06 east.

The area is approximately 100 acres in extent and is owned by the Natal Estates (Pty.) Ltd., who have effectively protected it since the turn of the century. It is bounded on the east by the National Highway, on the north by the Mhlanga River and on the remaining sides by sugarcane fields or abandoned farm lands (Plate 1).

**PHYSICAL FACTORS**

*Physiography*

The forest extends from 50 to 200 ft. above sea level on stabilised sand dunes. The soil is sandy and deep.

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† Accepted for publication 1st August, 1967.

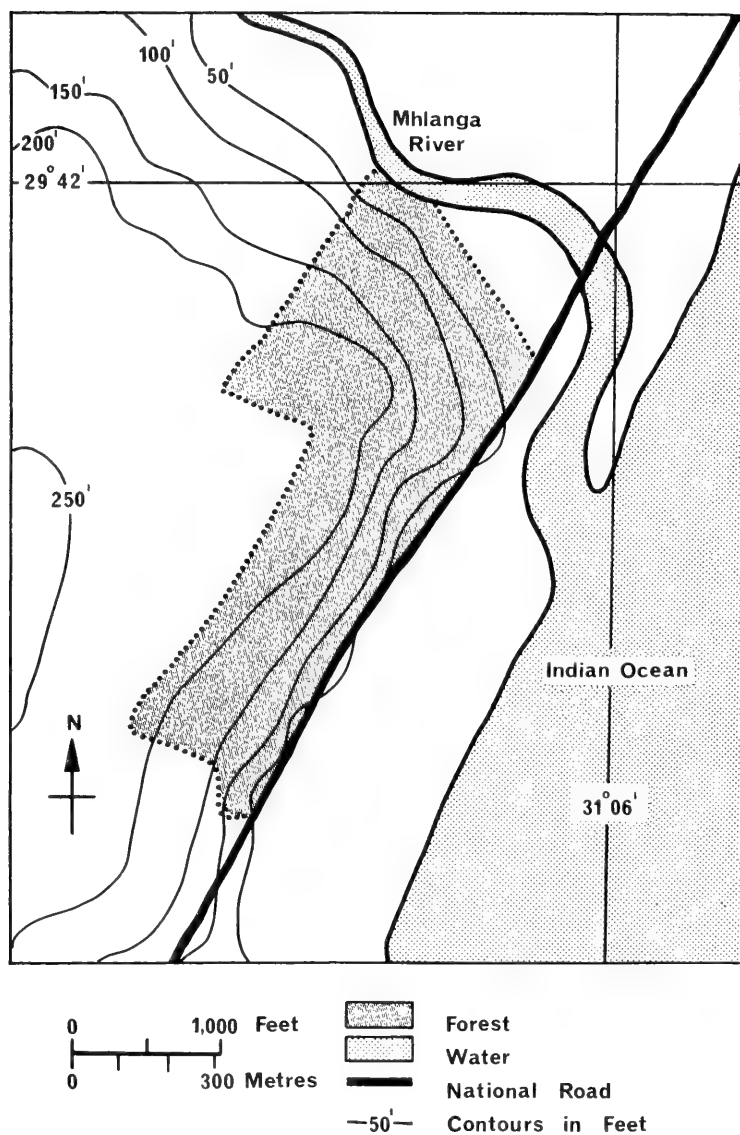


FIG. 1.  
Map of Hawaan forest.



PLATE 1.

*Albizia adianthifolia* (centre right), *Chrysanthemoides monilifera* (centre and right) and *Helichrysum kraussii* are common forest pioneers on abandoned farm lands. Note the sandy soil and the climax forest in the background.

Topographically the area comprises three aspects: (i) a relatively flat area above 200 ft; (ii) a fairly steep sea-facing slope of  $10^{\circ}$  to  $30^{\circ}$ , which is interrupted by the National Highway; and (iii) a steep slope of  $25^{\circ}$  to  $30^{\circ}$  down to the Mhlanga River (see Fig. 1).

#### Climate

Climatic data are available from two nearby stations: Durban Bluff, ten miles to the south, and Mt. Edgecombe, three miles inland to the west (Weather Bureau, 1954). Summarized rainfall and temperature data for these two stations are illustrated graphically (Walter, 1963) in Fig. 2. Summers are warm and wet and winters are mild and dry in comparison.

The prevailing winds are from the northeast (sea breezes) and southwest (rain bearing), the former carrying salt spray from the sea on to the forest canopy. The effect of the salt spray is most appreciable on that corner of the forest nearest the Mhlanga River (Fig. 1), where low dunes at the river mouth afford little shelter from sea breezes. Elsewhere along the coast the high dunes afford some protection to the remainder of the forest.

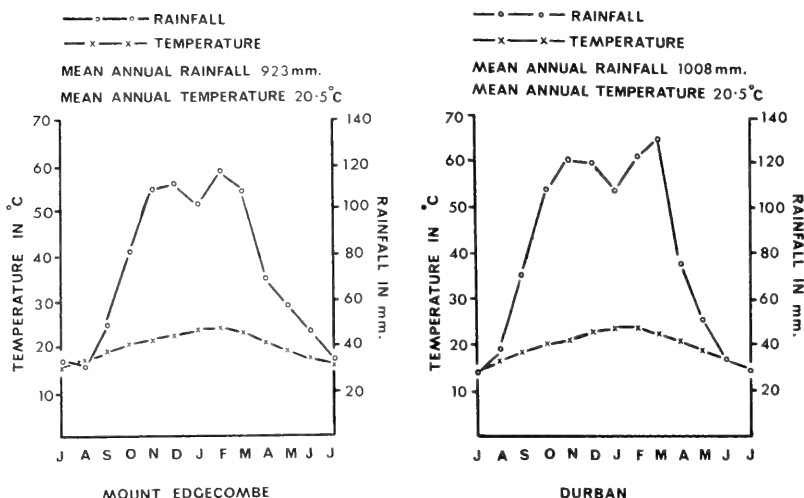


FIG. 2.  
Summarized climatic data for Durban and Mt. Edgecombe.

#### VEGETATION

##### Forest margin

The forest margin is not well developed because the forest has been damaged on all sides, except on the north adjacent to the river (Plate 2).

Where the forest has been encroached upon by sugarcane lands there is a luxuriant growth of marginal trees and lianes which form an effective barrier to light and wind penetration beneath the canopy. Common trees colonizing such areas are *Sapium integerrimum*, *Allophylus natalensis*, *Albizia adianthifolia*, *Ziziphus mucronata* and *Brachylaena discolor*. Common lianes are *Grewia caffra*, *Scutia myrtina*, *Acacia kraussiana* and *Dalbergia armata*.

On the seaward side, however, where a National Highway has been carved through the forest, the margin has not become overgrown due to the killing of exposed trees and seedlings by the wind-carried salt-spray. The first and sometimes the second line of trees, exposed when the road was cut through the forest some 5 years ago, have been killed by exposure to salt spray (Plate 3). Common species on this margin are shrubs such as *Peddiea africana*, *Uvaria caffra*, *Carissa bispinosa*, *Chrysanthemoides monilifera* and the grass, *Panicum chusqueoides*. Few lianes are present and in some more sheltered parts trees such as *Deinbollia oblongifolia*, *Euclea natalensis*, and *Croton sylvaticus* are found.



PLATE 2.  
Hawaan forest, as seen from the Mhlanga River, showing the only undamaged margin and the fairly even canopy.



PLATE 3.  
The destruction caused by salt spray to the section of forest cleared for the National Road.

*Climax forest*

The Hawaan forest is considered to be climax forest as there is no direct evidence of exploitation apart from the removal of dead branches for firewood and the very occasional cutting of trees.

There are three distinct forest facies which are related to the topography and aspect.

a) *Structure*. The forest on the flat and on the seaward slope comprises four strata: canopy, sub-canopy, shrub and herbaceous field layer. The forest on the river slope has three strata: canopy, shrub and herbaceous field layer. The numerous lianes present throughout are a feature of Natal dune forest.

The height of the continuous upper canopy is variable and on the flat and seaward slopes may be from 30 to 60 ft high (Figs. 3 & 4), while on the river slope the canopy is shorter, from 20 to 40 ft high.

The sub-canopy tree layer is discontinuous and not well developed; trees vary in height from 10 to 40 ft.

The shrub layer, from two to eight feet high, is discontinuous and is best developed on the flat ground where an almost continuous layer is formed. On the seaward slope the shrub layer is poorly developed and on the steep river slope the shrub layer is sparse, except where the canopy is broken.

The herbaceous field layer is sparse throughout, particularly on the river slope where the forest-floor is almost bare.

Lianes are common throughout, although most abundant on the seaward and river slopes. They increase the density of the canopy considerably and effectively seal off small gaps. Very rarely is the weight of lianes sufficient to cause mechanical breakage of branches, as is the case in forests further inland (Moll, 1965).

A feature of Hawaan is that many canopy trees are not upright (Plate 4). Once a tree-crown reaches the canopy and is subjected to gusty winds, the poor anchorage provided by the sandy soil often results in the tree being blown out of the vertical. As the direction of gusty winds is inconsistent, angle of lean is variable. The only canopy tree species which is always erect is *Celtis africana* and this may be attributed to the well-developed spur buttresses.

An important factor affecting the forest structure is the high erodibility of the sandy soil, particularly on the steep slopes which do not offer a stable substrate for seedling germination. This area is subject to sheet erosion causing root systems to be exposed (Plate 5); on such areas the forest is short and dense, comprising mainly pioneer species.



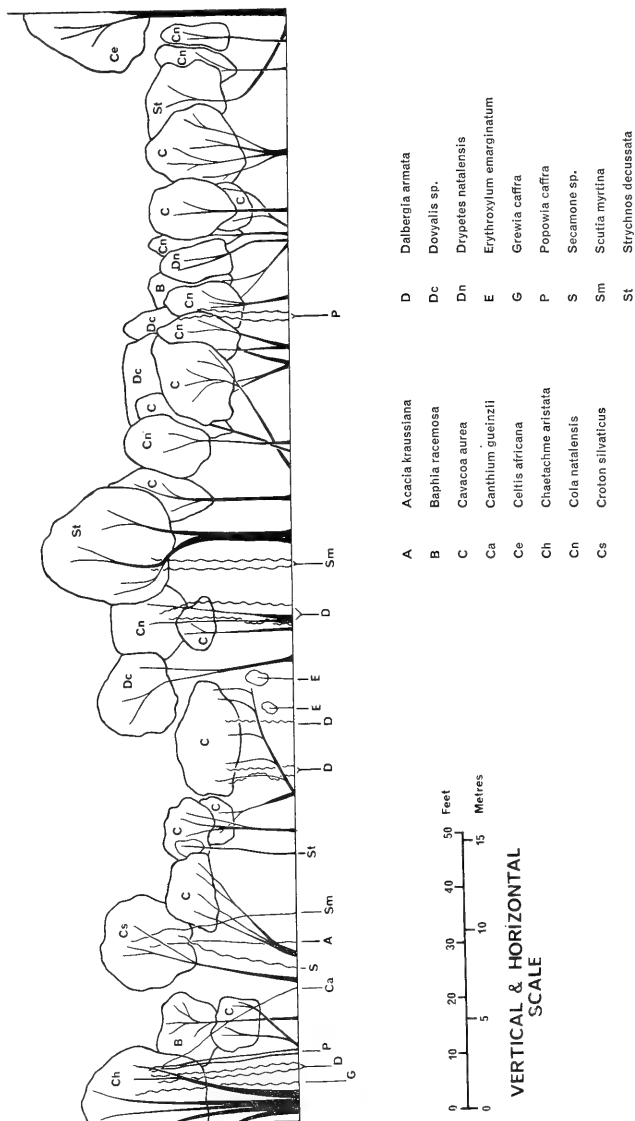


FIG. 3.  
Profile diagram (belt 200 x 25 ft) through climax forest.

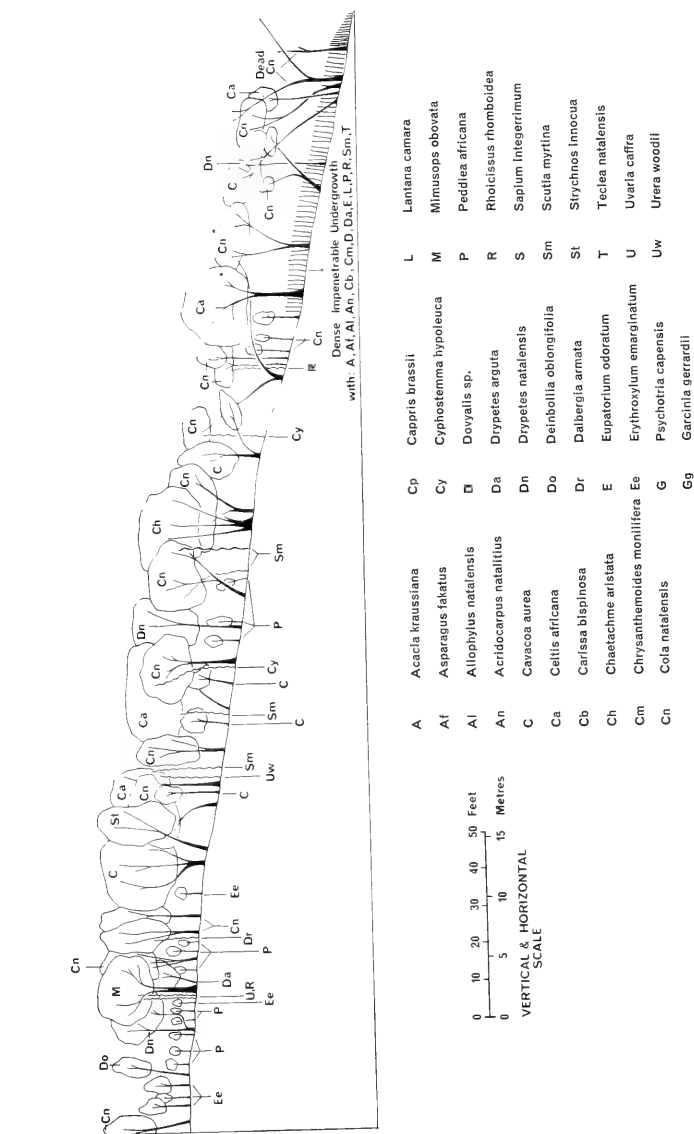


FIG. 4.  
Profile diagram (belt 300 x 25 ft) through the forest on the sea slope, showing a section from the disturbed margin into sub-climax forest.



PLATE 4.

An example of the sandy soil offering poor anchorage is this specimen of *Cavacoa aurea*. The roots exposed on the right were lifted from the soil when the tree was shifted.



PLATE 5.

Illustrating the highly erodible soil which on the steep slopes is readily washed away exposing a mass of roots. Note the *Xylothea kraussiana* (centre left) which appears propped up on its roots.

b) *Composition*. Density values for trees and shrubs, counted as the number of stems per plot, were collected from fifty 33 ft square plots (a 10% sample). These data were also converted to frequency data on the basis of the 33 ft square plots. Presence or absence of selected herbaceous species was also noted. The plots were located by restricted randomization; a grid being placed over the forest and three plots located within each grid square using random co-ordinates. Trees with a diameter at breast height (D.B.H.) of more than three inches and over 15 ft high were counted as canopy trees, all other woody plants being considered shrubs (lianes excluded). Additional data recorded were D.B.H. and height of canopy trees. All these data have been summarized and are shown in tables 1-5.

TABLE 1.  
Mean density per acre of common trees and their local frequency, expressed as a percentage, in Hawaan forest

Species	12 River Plots		12 Sea Plots		26 Flat Plots		Total 50 Plots	
	Den. Acre	% Freq.	Den. Acre	% Freq.	Den. Acre	% Freq.	Den. Acre	% Freq.
<i>Cola natalensis</i>	46	34	134	92	135	85	111	74
<i>Xylothea kraussiana</i> var. <i>glabrifolia</i>	134	92	17	25	0	0	36	28
<i>Cavacoa aurea</i>	9	17	25	17	42	50	30	34
<i>Celtis africana</i>	29	50	0	0	14	23	14	24
<i>Drypetes natalensis</i>	21	42	29	50	2	4	13	24
<i>Teclea natalensis</i>	4	8	46	34	2	4	13	12
<i>Dovyalis</i> sp.	21	34	4	8	12	20	12	20
<i>Strychnos innocua</i>	4	8	9	8	17	27	12	18
<i>Deinbollia oblongifolia</i>	38	59	9	17	0	0	11	18
<i>Mimusops obovata</i>	17	34	25	42	0	0	10	18
<i>Strychnos decussata</i>	4	8	0	0	14	27	8	16
<i>Diospyros natalensis</i>	17	34	9	17	2	4	7	14
<i>Chaetachme aristata</i>	9	8	17	34	0	0	6	10
<i>Croton sylvaticus</i>	0	0	4	8	8	16	5	10
<i>Sapium integerrimum</i>	13	17	0	0	4	4	5	6
<i>Euclea natalensis</i>	9	17	0	8	2	4	4	8
<i>Olea capensis</i>	4	8	9	17	2	4	4	8
<i>Ziziphus mucronata</i>	4	8	9	17	0	0	4	6
Average No. of stems/acre	380		350		250		350	

(i) *Trees*. Hawaan is characterized by the importance of *Cola natalensis* and *Cavacoa aurea* in the canopy. Both species have a high density, but occur predominantly on the flat and sea-facing slopes. The third most abundant tree, *Xylothea kraussiana*, occurs almost entirely on the river-facing slope. Hawaan is unique in the Republic of South Africa as no other similar forest types have such an abundance of *Cola natalensis* and *Cavacoa aurea*. The latter is particularly rare and has been found in only one other place, the Dukuduku forest at St. Lucia, where it occurs in a very small localized patch.

Average density per plot shows that the flat area has lowest density and the river aspect highest density. Observations suggest that the flat area is a true climax stage and that the sea and the river slopes are seral stages (or sub-climax stages).

From the frequency values *Cola natalensis*, *Cavacoa aurea*, *Celtis africana*, *Dovyalis* sp. (E.J.M. 1837), *Strychnos innocua* and *Strychnos decussata* are the most important climax trees. On the sea slope *Xylothea kraussiana*, *Drypetes natalensis*, *Teclea natalensis*, *Mimusops obovata* and *Chaetachme aristata* are the most common sub-climax species, while on the river slope *Xylothea kraussiana*, *Drypetes natalensis*, *Deinbollia oblongifolia*, *Mimusops obovata* and *Diospyros natalensis* are the most common sub-climax trees.

Data for average D.B.H. and average height of trees (Table 2) indicate that the largest trees occur on the flat ground and the smallest trees on the river slope.

TABLE 2.  
Average, estimated D.B.H. and Height of trees in Hawaan forest

	River Slope	Sea Slope	Flat Ground
D.B.H. in inches . . . . .	4.5	5.0	8.0
HEIGHT in feet . . . . .	19	23	28

(ii) *Shrubs*. Shrubs are numerous in Hawaan and only the most common are given in Table 3.

TABLE 3.  
Mean density per acre of the principal shrubs and their local frequency, expressed on a percentage, in Hawaan forest

Species	12 River Plots		12 Sea Plots		26 Flat Plots		Total 50 Plots	
	Den. Acre	% Freq.	Den. Acre	% Freq.	Den. Acre	% Freq.	Den. Acre	% Freq.
<i>Notobuxus natalensis</i> . . . . .	4	8	9	8	623	43	327	26
<i>Uvaria caffra</i> . . . . .	288	84	188	100	383	97	313	94
<i>Drypetes natalensis</i> . . . . .	46	59	204	92	198	85	162	80
<i>Acridocarpus natalitius</i> . . . . .	25	8	134	34	225	70	156	46
<i>Drypetes arguta</i> . . . . .	38	42	54	42	225	89	141	66
<i>Erythroxylum emarginatum</i> . . . . .	129	84	117	59	163	85	141	78
<i>Cola natalensis</i> . . . . .	4	8	117	50	204	66	135	48
<i>Baphia racemosa</i> . . . . .	146	67	179	67	62	85	134	76
<i>Dovyalis</i> sp. . . . .	100	42	63	50	97	73	88	60
<i>Diospyros natalensis</i> . . . . .	125	42	109	67	54	50	84	52
<i>Peddiea africana</i> . . . . .	4	8	175	84	40	43	64	44
<i>Carissa acuminata</i> . . . . .	46	50	54	67	44	35	47	46
<i>Putterlickia verrucosa</i> . . . . .	42	42	79	59	32	20	45	34
<i>Grewia occidentalis</i> . . . . .	50	34	67	17	15	20	36	22
<i>Dracaena hookeriana</i> . . . . .	17	17	100	42	10	8	32	18
<i>Cassine papillosa</i> . . . . .	42	34	9	17	21	9	21	30
Average No. of stems/acre	1200		1655		2390		1925	

*Notobuxus natalensis* has the highest recorded density yet it has a low percentage frequency. It always occurs in localized patches, usually to the exclusion of all other shrub and herb species.

Shrub density and frequency data are much higher than the tree data and the shrubs are most dense on the flat area, apparently due to recent disturbance. The shrubs on the river slope have the lowest density because of the steep slope and highly erodible soil.

The shrub frequency data show a pattern associated with site aspect, although it is not as distinct as that shown by the canopy trees, as shrubs are more dependant on canopy density and the amount of disturbance than on the external environment. *Baphia racemosa*, *Uvaria caffra*, *Erythroxylum emarginatum* and *Drypetes natalensis* are more or less ubiquitous while *Acridocarpus natalensis* and *Drypetes arguta* are most common in the flat plots. *Cola natalensis*, *Dovyalis* sp. (E.J.M. 1837) and *Diospyros natalensis* are most common on the sea and flat slopes. *Peddiea africana* and *Putterlickia verrucosa* are most common on the sea-facing slopes and *Carissa acuminata* occurs mainly on the river slope. (iii) *Herbs*. Only the more common herbs were recorded as being either present or absent. These data are given in Table 4.

TABLE 4.  
Local frequency of the most common herbaceous species in Hawaan forest

Species	Percentage Frequency			
	12 River Plots	12 Sea Plots	26 Flat Plots	Total 50 Plots
<i>Panicum chusqueoides</i> . . . . .	100	92	73	84
<i>Oplismenus hirtellus</i> . . . . .	8	84	97	72
<i>Cyperus albostratus</i> . . . . .	42	67	43	48
<i>Cyphostemma hypoleuca</i> . . . . .	92	25	34	36
<i>Eriospermum natalensis</i> . . . . .	8	67	75	36
<i>Achyranthus aspera</i> . . . . .	34	8	23	22
<i>Commelina</i> sp. . . . .	25	25	8	16

*Oplismenus hirtellus* and *Eriospermum natalensis*, being climax forest herbs, are most common on the sea and flat sites. *Panicum chusqueoides*, a secondary species, is an indicator of recent disturbance.

(iv) *Lianes*. Lianes, being very common in Hawaan, are important ecologically as they add greatly to the density of the canopy. Numerous species are present yet their distribution in relation to aspect of sites is not clear (Table 5). *Dalbergia armata*, though ubiquitous, occurs mainly on the river and sea slopes. *Acacia kraussiana* and *Capparis* spp. occur mainly on the river slopes. *Behnia reticulata*, *Rhoicissus rhomboidea* and *Scutia myrtina* are most common on the sea slope and *Cyphostemma hypoleuca* is most frequent on the sea and flat slopes.

TABLE 5.  
Local frequency of lianes in Hawaan forest

Species	Percentage Frequency			
	12 River Plots	12 Sea Plots	26 Flat Plots	Total 50 Plots
<i>Dalbergia armata</i>	83	42	70	62
<i>Acacia kraussiana</i>	75	42	43	50
<i>Capparis</i> spp.	75	42	31	42
<i>Secamone</i> spp.	42	34	43	40
<i>Behnia reticulata</i>	0	75	39	36
<i>Cyphostemma hypoleuca</i>	17	50	43	34
<i>Adenia hastata</i>	33	25	35	32
<i>Asparagus falcatus</i>	17	25	39	30
<i>Rhoicissus rhomboidea</i>	17	42	27	28
<i>Scutia myrtina</i>	25	59	8	24
<i>Rhoicissus tomentosa</i>	17	17	23	20
<i>Asparagus plumosus</i>	8	0	35	20
<i>Flagellaria guineensis</i>	33	17	8	16
<i>Rhoicissus cuneifolius</i>	0	34	16	16
<i>Uvaria caffra</i>	0	17	20	14
<i>Popowia caffra</i>	0	17	12	10
<i>Urera woodii</i>	0	8	16	10
<i>Dalbergia obovata</i>	8	0	4	4
<i>Grewia caffra</i>	0	0	4	2

c) *Gap Succession*. Gaps in the forest canopy are not common in Hawaan but once a gap forms it is rapidly filled by a growth of shrubs such as *Uvaria caffra*, *Baphia racemosa* and *Deinbollia oblongifolia*. Tree saplings are also common, especially *Cola natalensis*, *Croton sylvaticus* and *Ziziphus mucronata*. Lianes grow luxuriantly in the gaps, particularly *Dalbergia armata* and *Rhoicissus* spp. Old gaps which have subsequently closed over are marked by the increased local density of shrubs and lianes which are eventually shaded out.

#### DISCUSSION AND CONCLUSIONS

Hawaan is a comparatively well protected, unique area of forest north of Durban. The general ecology of the species is related to three topographically distinct aspects. The forest on the river and sea aspects are considered as seral to that on the flat area which is considered as climax forest.

The tabulated data collected from 50 random plots were subjectively sorted into three groups related to plot-aspect. By scanning the tables certain ecological preferences of some species could be seen and it was possible to conclude that *Cola natalensis*, *Cavacoa aurea*, *Celtis africana*, *Dovyalis* sp. (E.J.M. 1837) and *Strychnos innocua* were climax tree species, while *Xylothea kraussiana*, *Drypetes natalensis*, *Teclea natalensis*, *Deinbollia oblongifolia* and *Mimusops obovata* were sub-climax species. Similar conclusions were possible

concerning shrubs, herbs and, to some degree, lianes. The method was totally subjective yet functioned extremely well due to the three distinct facies represented at Hawaan.

#### ACKNOWLEDGEMENTS

I am very grateful to Natal Estates (Pty.) Ltd. for permission to work in the area, to Mr. J. W. Morris for many valuable comments and to the Chief, Botanical Research Institute and Secretary, Agricultural Technical Services for permission to publish this report.

#### PRELIMINARY CHECKLIST OF ANGIOSPERMS

Genera of angiosperms have been arranged according to Phillips's Genera of South African Flowering Plants (1951), and species within genera have been listed alphabetically. Numbers are my collectors numbers and specimens are housed in the National Herbarium, Pretoria, with duplicates in the Natal University Herbarium, Pietermaritzburg.

##### GRAMINEAE

<i>Panicum chusqueoides</i> Hack.	2981, 2983, 3094
<i>P. deustum</i> Thunb.	3114
<i>P. laticomum</i> Nees	2991
<i>P. maximum</i> Jacq.	seen only
<i>Digitaria diversinervis</i> (Nees) Stapf	3142, 3196
<i>Setaria verticillata</i> (L.) Beauv.	2988
<i>Dactyloctenium australe</i> Steud.	3112

##### CYPERACEAE

<i>Cyperus albostratus</i> Schrad.	seen only
<i>Mariscus dregeanus</i> Kunth	3119

##### FLAGELLARIACEAE

<i>Flagellaria guineensis</i> Schumach.	seen only
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##### COMMELINACEAE

<i>Commelina benghalensis</i> L.	1792
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##### LILIACEAE

<i>Chlorophytum modestum</i> Bak.	3138
<i>Asparagus falcatus</i> L.	1829
<i>A. plumosus</i> Bak.	1796, 3121
<i>Behnia reticulata</i> Didr.	1815
<i>Haemanthus magnificus</i> Herb.	1823

##### ORCHIDACEAE

<i>Microcoelia exilis</i> Lindl.	3124
<i>Mystacidium capense</i> Bol.	1811
<i>M. flanaganii</i> (L.f.) Schltr.	2845, 3273

##### ULMACEAE

<i>Celtis africana</i> Burm. f.	1838, 3088, 3225
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##### MORACEAE

<i>Ficus burtt-davyi</i> Hutch.	seen only
<i>F. polita</i> Vahl	seen only

##### URTICACEAE

<i>Urera woodii</i> N.E. Br.	2412, 3137
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##### LORANTHACEAE

<i>Loranthus kraussiana</i> Meisn.	2422
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##### AMARANTHACEAE

<i>Celosia trigyna</i> L.	3143, 3204
<i>Cyathula cylindrica</i> Moq.	2982, 3098
<i>Pupalia lappacea</i> (L.) Juss.	seen only
<i>Psilotrichum africanum</i> Oliv.	seen only
<i>Achyranthus aspera</i> L.	3115, 3149

##### NYCTAGINACEAE

<i>Commicarpus pentandrus</i> (Burch.) Heim.	3099
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##### PHYTOLACCACEAE

<i>Rivinia humilis</i> L.	3117
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##### MENISPERMACEAE

<i>Tinospora caffra</i> (Miers) Troupin	seen only
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##### ANNONACEAE

<i>Uvaria cafra</i> E. Mey. ex Sond.	2987, 3125
<i>Ariabotrys monteiroi</i> Oliv.	seen only

##### CRUCIFERAE

<i>Heliophila scandens</i> Harv.	1806
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##### CAPPARIDACEAE

<i>Capparis bassii</i> DC.	1795, 8219
<i>C. citrifolia</i> Lam.	3193, 3215
<i>C. tomentosa</i> Lam.	seen only
<i>C. zeyheri</i> Turcz.	3224
<i>Capparis</i> sp.	3215
<i>Maerua racemulosa</i> (A. DC.) Gilg & Ben.	1799, 3253

##### LEGUMINOSAE

<i>Albizia adianthifolia</i> (Schum.) W. F. Wright	1828
<i>Acacia kraussiana</i> Meisn.	2998
<i>Dichrostachys cinerea</i> (L.) Wight & Arn. subsp. <i>forbesii</i> (Benth.) Brenan & Brumitt	3123
<i>Baphia racemosa</i> Hochst.	2401, 2404, 2419, 3089, 3220
<i>Dalbergia armata</i> E. Mey.	1794

##### ERYTHROXYLACEAE

<i>Erythroxylum emarginatum</i> Thonn.	1814, 1830, 2395, 2405
<i>Nectaropetalum zuluensis</i> (Schonl.) Corbishley	1800



## RUTACEAE

- Teclea gerrardii* Verdoorn . . . . . 3087  
*T. natalensis* (Sond.) Engl. . . . . 2423, 2984, 3134

## MELIACEAE

- Turraea floribunda* Hochst. . . . . seen only  
*T. obtusifolia* Hochst. . . . . 3110

## MALPIGHIACEAE

- Acridocarpus natalitius* Juss. . . . . 2403

## EUPHORBIACEAE

- Tapura fischeri* Engl. . . . . 3217  
*Drypetes arguta* Hutch. . . . . 2394  
*D. natalensis* Hutch. . . . . 1835, 2414  
*Cavacoa aurea* (Cavaco) J. Leon. . . . . 2397, 2418,  
 2421, 3206  
*Croton sylvaticus* Hochst. . . . . 1797  
*Micrococca capensis* Prain . . . . . 3133  
*Erythrococca berberidea* Prain . . . . . 3277  
*Acalypha glabrata* Thunb. . . . . 2992  
*A. sonderiana* Mull. Arg. . . . . 3101  
*Suregada africana* (Sond.) Kuntze . . . . . 2413, 2415, 3127  
*Sapium integerrimum* (Hochst. ex Krauss). J.  
 Leon . . . . . 1821, 2979, 3194, 3208  
*Synadenium cupulare* (Boiss.) Wheeler . . . . . 3111

## BUXACEAE

- Notobuxus natalensis* Oliv. . . . . 1836, 2410

## ANACARDIACEAE

- Rhus natalensis* Bernh. . . . . 1818, 2989  
*R. nebulosa* Schönl. . . . . 3221

## CELASTRACEAE

- Maytenus undata* (Thunb.) Blakelock . . . . . 3201  
*M. procumbens* (L.f.) Loes . . . . . 3270  
*Putterlickia verrucosa* (E. Mey. ex Sond.)  
 Szyszyl . . . . . 1802  
*Cassine laurifolium* (Harv.) Davison . . . . . 3126  
*C. papillosa* (Hochst. ex Krauss) Kuntze . . . . . 2411, 2985  
 3102, 3198

## HIPPOCRATEACEAE

- Hippocratea schlechteri* Loes. var. *peglerae*  
 Loes. . . . . 3271

## SAPINDACEAE

- Allophylus natalensis* (Sond.) De Winter . . . . . 1803, 3222  
*A. melanocarpus* (Sond.) Radlk. . . . . 3129  
*Deinbollia oblongifolia* (Sond.) Radlk. . . . . 1798

## MELIANTHACEAE

- Bersama lucens* (Hochst.) Szyszyl. . . . . 3109

## RHAMNACEAE

- Ziziphus mucronata* Willd. . . . . 2408, 2993  
*Scutia myrtina* (Burm. f.) Kurz . . . . . seen only

## VITACEAE

- Rhoicissus rhomboidea* (E. Mey. ex Harv.)  
 Planch. . . . . 1812, 3092  
*R. tomentosa* (Lam.) Wild & Drummond . . . . . 3122  
*Cyphostemma* sp. cf. *cirrhosum* (Thunb.)  
 Descouings subsp. *transvaalensis* (Szyszyl.)  
 Wild & Drummond . . . . . 3095

## TILIACEAE

- Grewia caffra* Meisn. . . . . 2997, 3192  
*G. occidentalis* L. . . . . seen only

## MALVACEAE

- Abutilon grantii* A. Meuse . . . . . 1801

## STERCULIACEAE

- Cola natalensis* Oliv. . . . . 1810, 2396, 2399, 2402, 3211

## OCHNACEAE

- Ochna natalitia* (Meisn.) Walp. . . . . 3139

## GUTTIFERAE

- Garcinia gerrardii* Harv. . . . . 3199

## FLACOURTIACEAE

- Xylotheca kraussiana* Hochst. var. *glabrifolia*  
 Wild . . . . . 3089, 3120  
*Dovyalis* sp. . . . . 1837, 2986, 3099  
*D. rhamnoides* (Burch.) Harv. . . . . 2996

## PASSIFLORACEAE

- Adenia gummifera* (Harv.) Harms . . . . . 3096  
*A. hastata* (Harva.) Schinz . . . . . 3104

## THYMELIACEAE

- Peddiea africana* Harv. . . . . 1804, 2416, 3195

## RHIZOPHORACEAE

- Cassipourea gerrardii* Alston . . . . . 2407, 2417, 2420,  
 3131, 3203  
*C. gummiflua* Tul. . . . . seen only

## MYRTACEAE

- Eugenia capensis* Harv. . . . . seen only

## MYRSINACEAE

- Embelia ruminata* (E. Mey. ex A. DC.) Mez . . . . . 1827

## SAPOTACEAE

- Sideroxylon inerme* L. . . . . 3097  
*Mimusops caffra* E. Mey. ex A. DC. . . . . seen only  
*M. obovata* Sond. . . . . 3113, 3132, 3272

## EBENACEAE

- Euclea natalensis* A. DC. . . . . 1809  
*Diospyros natalensis* (Harv.) Brenan . . . . . 1834, 3091  
*D. villosa* (L.) De Winter var. *villosa* De Winter . . . . . 1817

## OLEACEAE

- Olea capensis* L. subsp. *enervis* (Harv. ex C. H.  
 Wr.) Verdoorn . . . . . 3108  
*O. capensis* L. subsp. *macrocarpa* (C. H. Wr.)  
 Verdoorn . . . . . 3200  
*Jasminum streptopus* E. Mey. . . . . 3275

## LOGANIACEAE

- Strychnos decussata* (Pappe) Gilg . . . . . 2409, 3141  
*S. innocua* Del. subsp. *gerrardii* (N.E. Br)  
 Verdoorn . . . . . 1813, 2398, 3255  
*S. henningii* Gilg . . . . . 3093, 3140, 3278, 3281  
*S. usambarensis* Gilg . . . . . seen only

## APOCYNACEAE

- Acokanthera oblongifolia* (Hochst.) Codd . . . . . 3274  
*Landolphia kirkii* Dyer . . . . . 2995

## ASCLEPIADACEAE

- Cynanchum ellipticum* R. A. Dyer . . . . . 3205  
*Secamone gerrardii* Harv. . . . . seen only

## CONVOLVULACEAE

- Ipomoea sinensis* (Desr.) Choisy . . . . . 3218

## VERBENACEAE

- Lantana camara* L. . . . . 1822  
*Clerodendrum glabrum* E. Mey. . . . . seen only  
*C. myricoides* (Hochst.) Vathe . . . . . 1839

## SOLANACEAE

- Cestrum laevigatum* Schltr. . . . . 1793

## SCROPHULARIACEAE

- Nemesia denticulata* (Benth.) Grant . . . . . 1824

## BIGNONIACEAE

- Tecomaria capensis* Spach . . . . . 1819

## ACANTHACEAE

- Thunbergia dregeana* Nees . . . . . 3100  
*Thunbergia* sp. . . . . 3218  
*Phaulopsis imbricata* (Forsk.) Sweet . . . . . 1825  
*Dicliptera heterostegia* Presl. ex Nees . . . . . seen only  
*D. mossambicensis* Klotzsch . . . . . 3213  
*Ruttya ovata* Harv. . . . . 3276  
*Justicia campylostemon* T. Anders. . . . . 3214  
*J. tubulosa* Lindau . . . . . 3212

## RUBIACEAE

- Xeromphis obovata* (Hochst.) Keay . . . . . seen only  
*Rothmannia globosa* (Hochst.) Keay . . . . . 1831  
*Tricalysia sonderiana* Hiern . . . . . 1808, 3103, 3223  
*Vangueria chartacea* Robyns . . . . . seen only  
*Lagynias lasiantha* (Sond.) Bullock . . . . . 3105

- Canthium ciliatum* (Klotzsch) Kuntze . . . . . 3107  
*C. gueinzii* Sond. . . . . 3130  
*C. mundianum* Cham. & Schlechtd. . . . . 1826  
*C. obovatum* Klotzsch . . . . . 1832, 3216, 3106  
*C. pauciflorus* (Klotzsch) Kuntze . . . . . 3197  
*C. ventosum* (L.) S. Moore . . . . . seen only  
*C. sp.* . . . . . 3197  
*Mitragma axillare* Hochst. . . . . 2994  
*Pavetta revoluta* Hochst. . . . . 2990, 3128, 3135  
*Psychotria capensis* (Eckl.) Vatke . . . . . 1807, 3202

## COMPOSITAE

- Vernonia angulifolia* DC. . . . . 3280  
*Eupatorium odoratum* L. . . . . 3210  
*Brachylaena discolor* DC. . . . . 1816, 3209  
*Helichrysum kraussii* Sch. Bip. . . . . 1790  
*Chrysanthemoides monilifera* (L.) T. Norl. . . . . 179

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## SOME NEW SPECIES OF ERICA†

H. A. BAKER

### ABSTRACT

Species hitherto not collected are, owing to the opening up of the Forest Reserves and a revival of interest in the Genus, frequently being brought in for identification and many collected previously are as yet un-named. The following group includes some in each category. They are from the higher mountains of the Southern Cape.

***Erica kougabergensis*** H. A. Baker sp. nov. (Ericaceae-Ericoideae) Pyronium.

Frutex erectus ad 45 cm. altus. *Rami* ascendentes, pubescentes, pilis paucis longioribus glandulosis admixis, glabrescentes. *Folia* 3-nata, 1.0—1.5 mm longa, patentia, imbricata, anguste ovata, sulcata, acuta vel dorsis apertis obtusis, glabra, similis bracteis et sepalis sparsim ciliata pilis setosis, glandulosis. *Flores* plerumque terminales sed aliquot subaxillares, umbelliformes, numero 3—6 varians, corollini, numerosi; pedunculi circa 2 mm longi, curvi, pubescentes pilis longioribus glandulosis admixis; bractee approximatae, 1.5 mm longae, anguste obovatae, sulcatae. *Sepala* 1.75 mm longa, anguste ovata, apicibus sulcatis, glabra. *Corolla* 2.5 mm longa, globoso-urceolata, sicca, glabra, rosea, lobis 0.5 mm longis, leviter effusis, obtusis. *Filamenta* plana, aliquantum curva; antherae exsertae, 0.75 mm longae, laterales, oblongae, obtusae, dorsis aliquantum curvis, bipartae, marginibus scabrosis, appendiculatae; poro fere dimidio pars lobi; aristae breves, basi latae, scabrae, caduces. *Ovarium* turbinatum, glabrum; stylo multo exserto; stigmatibus capitato.

CAPE PROVINCE. Uniondale District on the Kougaberg range. *Esterhuysen* 10797 near the Kouga Peak, Southern slopes 3000—4000 ft., 14/11/1944 (Holotype in Bolus Herbarium).

Erect shrub to about 45 cm. *Branches* ascending, villous with a few longer, gland-tipped hairs admixed, glabrescent. *Leaves* 3-nate, 1.0—1.5 mm long, spreading, imbricate, narrow-ovate, sulcate, acute to open-backed, obtuse and, like the bracts and sepals, glabrous and sparsely ciliate with gland-tipped, setose hairs. *Flowers* terminal in umbels of 3—6 flowers, a few axillary or appearing so, corolline, numerous; peduncles about 2 mm. long, curved, pubescent, with

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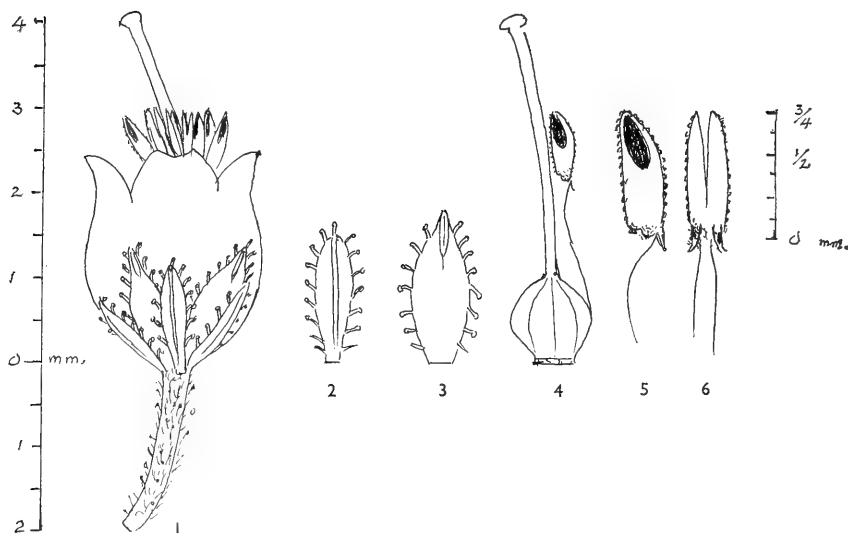


FIG. 1.

*Erica kougabergensis* H. A. Baker. 1. Flower; 2. bract; 3. Sepal; 4. gynoecium and stamen; 5. anther, side view; 6. anther, back view.

Del. H. A. Baker.

longer, gland-tipped hairs admixed; bracts approximate, 1.5 mm long, narrow obovate, sulcate. *Sepals* 1.75 mm long, narrow-ovate, sulcate-keel-tipped. *Corolla* 2.5 mm long, globose-urceolate, dry, glabrous, rose; lobes 0.5 mm long, slightly spreading, obtuse. *Filaments* broad and somewhat curved; anthers exserted, 0.75 mm long, lateral, oblong, obtuse, somewhat curved dorsally, bipartite, roughly scabrid on the margins, appendiculate; awns broad-based and short, deciduous, rough. *Ovary* turbinate, glabrous; style long-exserted; stigma capitate.

This species from the same general area as *E. granulosa* H. A. Baker has many characters in common with the latter. These are discussed in the description of that species, q.v. It is probable that the distribution of both is confined to this range.

***Erica granulosa* H. A. Baker sp. nov.** (Ericaceae-Ericoideae) Pyronium.

Frutex erectus ad 45 cm. altus. *Rami* ascendentes, numerosi, villosi, pilis brevibus, albis, interdum glandulosis, glabrescentes. *Folia* 3-nata, 1—1.5 mm longa, patentia, imbricata vel appressa et circa ad internodis equalibus, saepe

in idem ramo, lineari versus anguste ovata, trigona, acuta, crassa, glabra, sparsim ciliata pilis setosis interdum glandulosis. *Flores* plerumque terminales sed aliquot axillares, umbelliformes, numero 1—6 variants, corrolini, plus minusve cernui, numerosi; pedunculi 1.5—2 mm longi, pilis ut in ramis; bracteae in mediano, ad sepalis similaribus sed angustioribus. *Calyx* leviter gamosepalus; sepalia 0.75 mm longa, variabilia saepe in eadem planta, ab oblongis, cuneatis ad ovatis vel obovatis, apicibus minute carinatis, glabra, ciliata pilis setosis inequalibus interdum glandulosis, scariosa, alba. *Corolla* circa 1.5 mm longa, globoso-urceolata, sicca, granulata, glabra, alba vel subrosea; lobis 0.5 mm longis, leviter effusis, obtusis. *Filamenta* plana, gracilia; antherae subexsertae, 0.5 mm longae, laterales, oblongae, obtusae, bipartae, scabridae, appendiculatae; poro fere pars tertia lobi; aristae angustae, fere pars tertia lobi, scabridiusculae. *Ovarium* late-ovatum, villosum apprimè ad apicem; stylo multo exserto; stigmatè capitato.

CAPE PROVINCE. Uniondale District. Southern slopes of Mannetjiesberg c. 4,500 ft., frequent. *Williams* 1073, 23/9/1967 (Holotype in BOL.), Kougaberg Mts. Smutsberg c. 5,000 ft., white or pinkish, *Esterhuysen* 10761, 12/11/1944 BOL, NBG.



PLATE I.  
*Erica granulosa* H. A. Baker. Sprig. Photo: H. A. Baker.

Erect shrub to about 45 cm. *Branches* ascending, numerous, shortly villous with white, sometimes gland-tipped hairs, glabrescent. *Leaves* 3-nate, 1—1.5 mm long, spreading and imbricate or adpressed and about equalling the internodes, often on the same branch, linear to narrow-ovate, trigonous, acute, thick, glabrous, sparsely ciliate with setose, sometimes gland-tipped hairs. *Flowers* mostly terminal but a few axillary in umbels of 1—6 flowers, corolline, more or less cernuous, numerous; peduncles 1.5—2 mm long, shortly villous with some gland-tipped hairs admixed; bracts median, like the sepals but narrower. *Calyx* slightly gamosepalous; sepals 0.75 mm long, variable in shape, often on the same flower, from oblong-cuneate to ovate or obovate, minutely keel-tipped, glabrous, irregularly setose-ciliate with some gland-tipped hairs admixed, scarious, white or pinkish. *Corolla* about 1.5 mm. long, globose-urceolate, dry, granulate, glabrous, white (in the type) or pinkish; lobes 0.5 mm long, slightly spreading, obtuse. *Filaments* flat, slender; anthers sub-

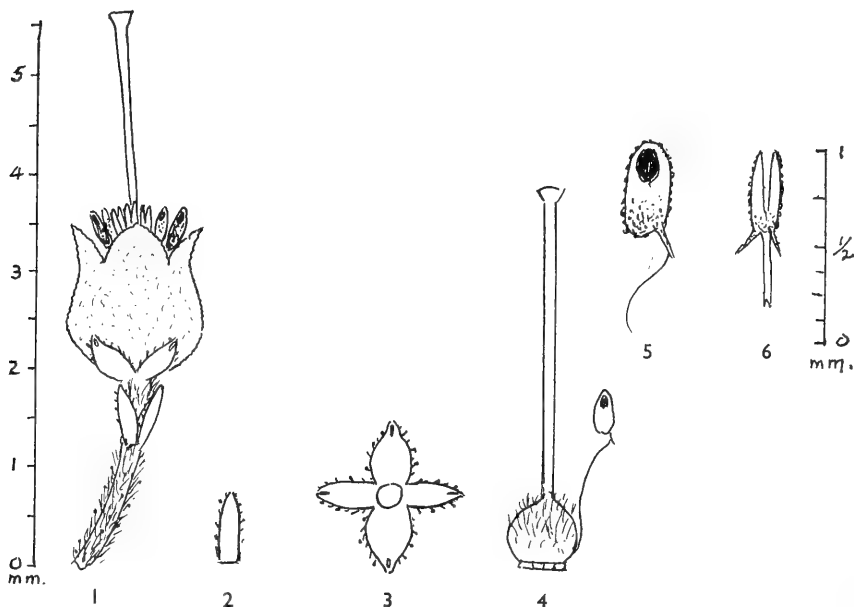


FIG. 2.

*Erica granulosa* H. A. Baker. 1. Flower; 2. bract; 3. calyx flattened out; 4. gynoecium and stamen; 5. anther, side view; 6. anther, back view.

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exserted, 0.5 mm. long, lateral, oblong, obtuse, bipartite, scabrid, appendiculate; pore about  $\frac{1}{3}$  the length of the cell; awns narrow, about  $\frac{1}{3}$  the length of the cell, rough. *Ovary* broad-ovate, villous especially at the apex; style long-exserted; stigma capitate.

*Erica granulosa* is one of those species with very numerous, small flowers that may be mistaken for a minor genus and overlooked by the collector. It is, however, as interesting botanically as many of the more showy ones. Unlike most in this section it is provided with glandular hairs on most parts except the corolla which is peculiar in being covered with granules of a microscopic size. Another species collected in the same general area on Kougaberg by Esterhuysen (10761) is very similar in some ways, particularly in having gland-tipped hairs on most parts, but the leaves are different, the bracts differently placed, the corolla 1 mm longer and red, without granules. There are other differences such as the type and quality of the hairs, the shape of the anthers and the glabrous ovary which, taken as a whole, would appear to debar this from being considered a variety of *E. granulosa*. It has been described separately as *Erica kougabergensis*. There is also some superficial resemblance to *E. harveyana* Guthrie & Bolus but, on closer study, there are many important differences.

The full distribution of this species is not yet known but it would seem likely that it is confined to the mountains in this District at an altitude of 3,000 ft. and above.

The author is indebted to Mr. Ion Williams for collecting this species and introducing him to it.

***Erica valida* H. A. Baker sp. nov.** (Ericaceae-Ericoideae) Ephebus.

Frutex erectus, robustus ad 45 cm altus. *Rami* ascendentes, pubescentes, pilis longioribus glandulosis admixis, glabrescentes. *Folia* 4-nata, 5 mm longa, squarrosa, late lineari vel oblonga, obtusata, profunde interdum late sulcata, crassa, rigida, instructa, pro parte maxima ad margine, pilis setosis, longitudinum differentium, senioribus glandulosis, caducis. *Flores* terminales, pro parte maxima 4-nata, interdum umbelliformes; pedunculae plus minusve 10 mm longae pilis similibus ramis sed plus persistentibus; bractae 2 mm longae, ad medium positae, angustae, pubescentes, ciliatae pilis glandulosis. *Sepala* 3.5—4.0 mm longa, anguste ovata, foliacea sed glandulibus plus persistentibus. *Corolla* circa 8 mm. longa, ovato-urceolata, sicca, villosa, rosea; lobis 1 mm longis, leviter effusis, obtusis. *Filamenta* sursum contracta; antherae inclusae, 1.5 mm longae, laterales, oblongo-cuneatae, bipartae, scabruisculae, appendiculatae; poro fere pars tertia lobi; aristae 0.25 mm longae, subulatae, asperae. *Ovarium* late turbinatum, villosum; stylo exserto; stigma capitellato.

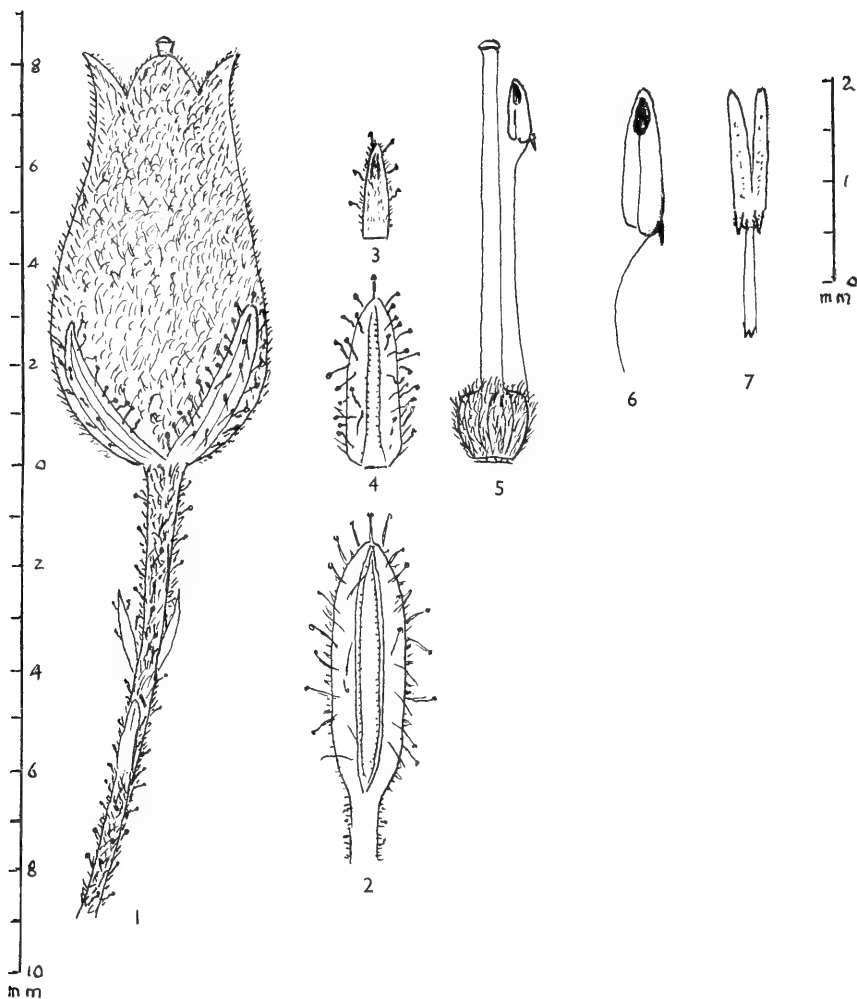


FIG. 3.

*Erica valida* H. A. Baker. 1. Flower; 2. leaf, under side; 3. bract; 4. sepal; 5. gynoecium and stamen; 6. anther, side view; 7. anther, back view.

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CAPE PROVINCE. Uitenhage District. Great Winterhoek Mountains, Cockscomb on rocks and cliffs facing South and the South-facing ridge 5,600—5,700 ft. *Esterhuysen* 28020, 30/11/1958 (Holotype in Bolus Herbarium); Kommassie Mts., Mannetjiesberg between rocks at the base of cliffs, *Esterhuysen* 18386, 8/3/1951, when flowers were over, *Bond* 933, 1/2/1944 (NBG).

Erect robust shrub to 45 cm or so. *Branches* ascending, pubescent with longer, gland-tipped hairs admixed, glabrescent. *Leaves* 4-nate, 5 mm long, squarrose, broad linear to oblong, obtuse, deeply and sometimes widely sulcate but scarcely open-backed, thick and rigid, beset, mostly on the margins, with setose hairs of variable length, the longer gland-tipped, the glands soon deciduous. *Flowers* terminal, mostly 4-nate, sometimes umbellate; peduncles more or less 10 mm long, with hairs like those on the branches but more persistent; bracts 2 mm long, median, the lowest sometimes more distant, narrow, pubescent, ciliate with gland-tipped hairs. *Sepals* 3·5—4 mm long, narrow-ovate, foliaceous but the glands more persistent. *Corolla* about 8 mm long, ovate-urceolate, dry, villous, rose; lobes 1 mm. long, slightly spreading, obtuse. *Filaments* tapering upwards; anthers included, 1·5 mm long, lateral, oblong-cuneate, bipartite, scabridulous, appendiculate; pore about  $\frac{1}{3}$  of the cell; awns 0·25 mm long, subulate, rough. *Ovary* broad-turbinate, villous: style included or slightly exserted; stigma capitate.

This species has some resemblance to *E. lignosa* but has many differences on closer inspection. The remote bracts place it in a different part of the key in *Flora Capensis* and it is not very closely related to any of those described. The anthers are awned and not crested as in *lignosa*.

It appears to be confined to the highest mountains in this District.

***Erica lignosa* H. A. Baker sp. nov.** (Ericaceae-Ericoideae) Epheb. s.

Frutex erectus, lignosus ad 15 mm altus. *Rami* numerosi, ascendentes, tomentosi, pilis paucibus longioribus, glandulosi, admixis, senioribus cicatricibus pulvinis, glabrescentes. *Folia* 4-nata, fere 2 mm longa, patentia, imbricata, late lineari vel anguste ovata, acuta, crassa, rigida, super et infra pubescentia, sparsum ciliata pilis glandulosi, glabrescentia. *Flores* terminales, umbelliformes, numero 1—6 varians; pedunculae fere 5 mm longae, pilis similibus ramis; bractae approximatae similes sepala sed parviora et anguste obovatae. *Sepala* 3·0 mm longa, oblonga, cuneata, carinata, tomentosa pro parte maxima secus carinam, ciliata pilosis glandulosi admixis, rubra. *Corolla* 5 mm longa, urceolata, fauce angustata, sicca, pubescens, rubra; lobis 1 mm. longis leviter effusis, obtusis. *Filamenta* sursum contracta; antherae inclusae, 1·5 mm longae, prope basin affixae, angustae, oblongae, cuneatae, bipartae, scabriusculae, appendiculate; poro fere pars quarto lobi; cristae 0·25 mm longae, latae, puncto

longo, plus minusve laceratae vel incisae. *Ovarium* ovatum, pubigerum; stylo exserto; stigmatibus capitellato, 4-dentato.

CAPE PROVINCE. Prince Albert District, Swartberg Pass, 6,000 ft. *Esterhuysen* 4775, 25/1/1941 (Holotype in Bolus Herbarium). Flowers in mid-summer. Also collected by *Taylor* 1091, 17/1/1954 (BOL.) and *Stokoe* s. n. (SAM 62317) Jan. 1947, both in the same locality.

A dwarf, woody shrub to about 6 inches in height. *Branches* numerous, ascending, the older scarred with the persistent leaf cushions, white-tomentose with a few longer gland-tipped hairs admixed, glabrescent. *Leaves* 4-nate, about 2 mm long, spreading, closely set and imbricate, the petioles adpressed, broad-linear or narrow-ovate, sulcate, acute, thick and rigid, pubescent above and below and sparsely ciliate with gland-tipped hairs, glabrescent. *Flowers* in terminal umbels of up to 6 flowers; peduncles about 5 mm long with hairs as on the branches; bracts approximate, like the sepals but smaller and narrow-obovate. *Sepals* 3.0 mm long, oblong-cuneate, keeled, tomentose mostly along the keel and ciliate with some setose gland-tipped hairs admixed, red. *Corolla*

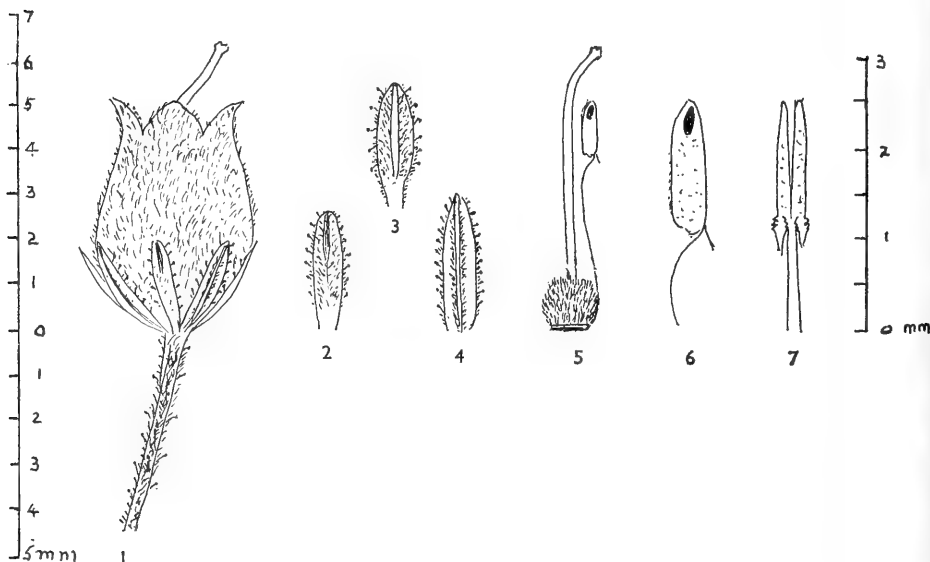


FIG. 4.

*Erica lignosa* H. A. Baker. 1. Flower; 2. bract; 3. leaf, underside; 4. sepal; 5. gynoecium and stamen; 6. anther, side view; 7. anther, back view.

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5 mm long, urceolate, dry, pubescent, red; lobes 1 mm long, slightly spreading, obtuse. *Filaments* tapering upwards; anthers included, 1.5 mm long, dorsally basifixed, narrow-oblong-cuneate, bipartite, scabridulous, appendiculate; pore  $\frac{1}{4}$  the length of the cell; crests 0.5 mm long, broad-based with a long apical point, more or less deeply incised or lacerate. *Ovary* ovate, pubigerous; style exserted; stigma capitellate, 4-toothed.

This species from the Karoo Region is one of the few in this section with 4-nate leaves, urceolate corolla and approximate bracts and is also distinct from the others described in having gland-tipped hairs on all parts except the corolla. It has, apparently, been collected only twice before and is, therefore, probably rare and confined to the tops of mountains in the Swartberg. It appears to be a very hardy species which is necessary for survival in the climate where it grows.

*Erica galgebergensis* H. A. Baker sp. nov. (*Ericaceae-Ericoideae*) Eurystoma.

Fruticulosus nanus, prostratus caudice lignoso persistenti. *Rami* ad basibus rigidis tum graciles, glabri. *Folia* opposita, circa 7 mm longa, patentia, imbricata, linearia, superne concava, sulcata, acutata, apiculata, pallide viridia, glabra; folia floralia interdum discoloria et bracteis simulantibus. *Flores* terminales, solitarii, vel raro 2-nati, calycosi; pedunculi 7 mm longi, glabri; bractea remotae, ad sepalis similibus sed parvioribus et angustioribus. *Sepala* 9 mm longa, ovato-acuminata, concava, laxa, apicibus carinatis, breviter excurrentibus, scariosa, glabra, alba. *Corolla* 8 mm longa ante et post maturitatem lobis erectis sed ad maturitatem 3 mm longa, tubo cyathiformi et lobis recurvatis; totum siccum, glabrum, 8-nervatum, album; lobi 5 mm longi, ovati, acutati, ad marginem minute laceratis. *Filamenta* aliquantum lata; antherae ad maturitatem exsertae, 2 mm longae, terminales, anguste oblongae, dorsis aliquantum curvis, basi scabridis, appendiculatae; poro fere tertia pars lobi; cristae in filamentis decurrentes per quasi dimidios longitudinis, apicibus liberis leviter effusis, varie incisae, totum circa 1.5 mm longum. *Ovarium* oblongum, profunde lobatum, glabrum; stylo ad maturitatem exserto; stigmate 4-lobatis.

CAPE PROVINCE. Robertson District. On rocky seepages on the Southern slopes of Galgeberg, Riviersonderende Mts. at more or less 4,250 ft. Marais s.n. BOL. (Holotype in Bolus Herbarium).

Flowers in October & November.

Dwarf, prostrate shrublet from a woody, persistent rootstock growing in seepages in the mist belt. *Branches* rigid below, slender above, scarred by the persistent leaf-cushions, glabrous. *Leaves* opposite, about 7 mm long, spreading, imbricate, linear, concave above, sulcate below, acute, apiculate, pale green,



PLATE 2.

*Erica galgebergensis* H. A. Baker. Growing plants.

Photo: S. W. Chater.

glabrous, the floral sometimes discolored and bract-like. *Flowers* terminal, solitary or, very occasionally 2-nate, calycine; peduncles 7 mm long, glabrous; bracts median, 5—6 mm long, sepal-like but narrower. *Sepals* 9 mm long, lax, ovate-acuminate, with a partly excurrent keel-tip, concave, scarious, glabrous, white. *Corolla* 8 mm long, before and after maturity but, when the



PLATE 3.

*Erica galgebergensis* H. A. Baker. Sprig. Photo: H. A. Baker.

lobes have spread horizontally and recurved, only 3 mm long and far exceeded by the sepals, the tube cyathiform, 3 mm long, the whole dry, glabrous, 8-veined, white; lobes 5 mm long, imbricate below, continuous or spreading in the manner of *E. calycina* L., ovate, acute, the margins minutely lacerate. *Filaments* broadish; anthers exerted at maturity, 2 mm long, terminal, narrow-oblong, somewhat curved at the back, scabrid on the lower part, appendiculate; pore  $\frac{1}{3}$  the length of the cell; crests decurrent on the filaments for more than half their length, then somewhat spreading, variously and deeply incised, the whole about 1.5 mm long. *Ovary* oblong, deeply lobed, glabrous, greenish below, white above; style exerted at maturity; stigma 4-lobed.

This attractive and unusual species grows on the extremely steep southern slopes of Galgeberg (Gallows Mountain) overlooking the narrow gorge that winds through the range. This slope receives an almost daily dose of misty cloud which creeps up the valley from the sea. It is thus a very damp area and has a very rich flora. *E. galgebergensis* grows in seepages here and there amongst the rocks and, due to this habit, is probably rare. It appears from the woody, lichen-covered, older branches to be a long-lived, fire-resistant species. It is not known how widely it is distributed but there is no record of its having been collected previously except by Mr. Marais in the same locality the previous year.

*E. galgebergensis* has been placed in the Section Eurystoma in which it bears some relation to *E. calycina*, particularly the var. *fragrans* Bolus. The habit of only displaying the anthers at maturity is common to both but it is considered to have sufficient individual characters, more especially its growth habit, to merit specific rank and not to be merely a variety of that extremely variable species. The North and South slopes of the mountain are very different. The North side is far less steep, gets little cloud and is, therefore, comparatively dry. On that side and on the summit at this time in flower were noticed *E. lutea* Berg., *E. denticulata* Salisb. and *E. monsoniana* L., and, on the wet side, *E. vallis-grateae* Guthrie & Bolus, *E. placentaeflora* Salisb., *E. carduifolia* Salisb., *E. calycina* and *E. brevifolia* Soland. ex Salisb.

The author wishes to acknowledge the help he received from Dr. L. Vogel-poel who arranged the trip on October 10th, 1967, and to Dr. P. P. du Toit of Robertson, a very successful grower of *Ericas* and to Mr. P. J. Marais of McGregor who accompanied him. Mr. Marais owns a piece of land on the lower slopes of the mountain and kindly arranged access to the summit on which is a Post Office tower and not normally accessible. He collected some of this species, then in an immature state and, as it was apparently a species unknown, the author asked him to collect some more later. This he very kindly did on November 11th and it is from this material that it has been described.

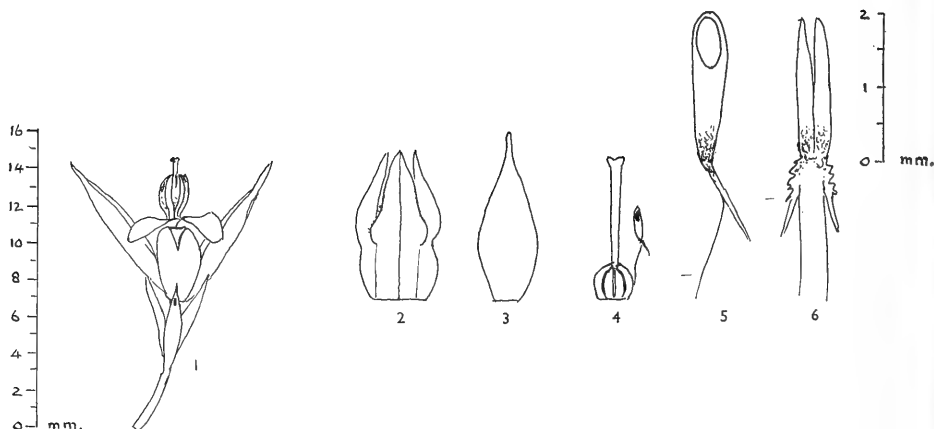


FIG. 5.

*Erica galgebergensis* H. A. Baker. 1. Flower at maturity; 2. Corolla before and after maturity; 3. sepal; 4. gynoecium and stamen; 5. anther, side view; 6. anther, back view. (5 and 6 much enlarged scale as indicated.)

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***Erica intricata* H. A. Baker** sp. nov. (Ericaceae-Ericoideae) Ceramia. Fruticulus diffusus ramis longis expansis intricatis, procumbentibus, caudice lignoso. *Rami*, folia, bracteae et sepala plus minusve villosi pilis intricatis longis, albis sed rami glabrescentes. *Folia* 3-nata, 3—5 mm longa, patentia, plus minusve late linearia, subacutata, sulcata vel dorsis longis apertis, mollia. *Flores* pro parte maxima 3-nata, terminales, sed interdum axillares; pedunculi 2—3 mm longi, glabri; bracteae remotae, inferior 1 mm longae sed superiores breviores. *Sepala* 1—1.5 mm glabri ovato-lanceolata, glabra. ciliata. *Corolla* 2.5 mm longa, late campanulato-cyathiformis, sicca, glabra, rosea; lobis 1.25 mm longis, continuis vel recurvis, obtusis. *Filamenta* debilia, plana, ad apice decrescens; antherae inclusae, 0.5 mm longae, laterales, oblongae, cunatae, bilobae, aristis 0.25 mm longis, basin versus affixis; poro fere  $\frac{1}{4}$ — $\frac{1}{3}$  pars lobi. *Ovarium* turbinatum, glabrum; stylo incluso vel manifesto; stigmatibus capiteo.

## DISTRIBUTION

CAPE PROVINCE. Paarl District: Haalhoek Sneeuwkop c. 3,500 ft., cliffs on slopes below the shale band, South side, overlooking Wemmershoek valley, growing on damp, shady, muddy faces and plastered to them. *Esterhuysen* 28224 (*Holotype* in Bolus Herbarium). Flowers in autumn (March).

A diffuse shrublet with long, spreading, intricate branches from a woody rootstock. *Branches*, leaves, bracts and sepals more or less villous with long, intricate, weak, white hairs, the branches rather sparsely so and glabrescent. *Leaves* 3-nate, 3—5 mm long, spreading, more or less broad-linear, subacute, sulcate to wide open-backed, pliant.

*Inflorescence* irregular, mostly terminal and 3-nate, but often with some axillary flowers below the terminal ones forming a cluster, and elsewhere: peduncles 2—3 mm long, glabrous; bracts remote, the lowest one 1 mm long, the upper pair smaller. *Sepals* 1.0—1.5 mm long, ovate-lanceolate, glabrous, ciliate. *Corolla* about 2.5 mm long, broad-campanulate-cyathiform, dry, glabrous, pale or darker pink; lobes 1.25 mm long, continuous and sometimes recurved, obtuse. *Filaments* flat, weak, tapering upwards; anthers included, 0.5 mm long, lateral, oblong, cuneate, bipartite, pale brown with awns about half as long as the cell, attached near its base, straight; pore  $\frac{1}{4}$ — $\frac{1}{3}$  the length of the cell. *Ovary* turbinate, glabrous; style included or manifest, stout; stigma capitate.

*E. intricata* appears to be very local and has only been collected once at this date. It was fairly abundant on the wet rock faces. Whilst it is typical of the Section *Ceramia* in habit of growth it does not seem to be closely related to any other species in that section. It is chiefly remarkable for its rather oddly-shaped, pliant leaves and the long, thin, intricate hairs on most parts except the corolla. The arrangement of the flowers is also unusual and is well shown in the drawing from which the hairs have been omitted as, being impossible to portray correctly on this scale, their inclusion would merely give a wrong impression.



FIG. 6.  
*Erica intricata* Sprig,  $3\times$  natural size, with hairs omitted.

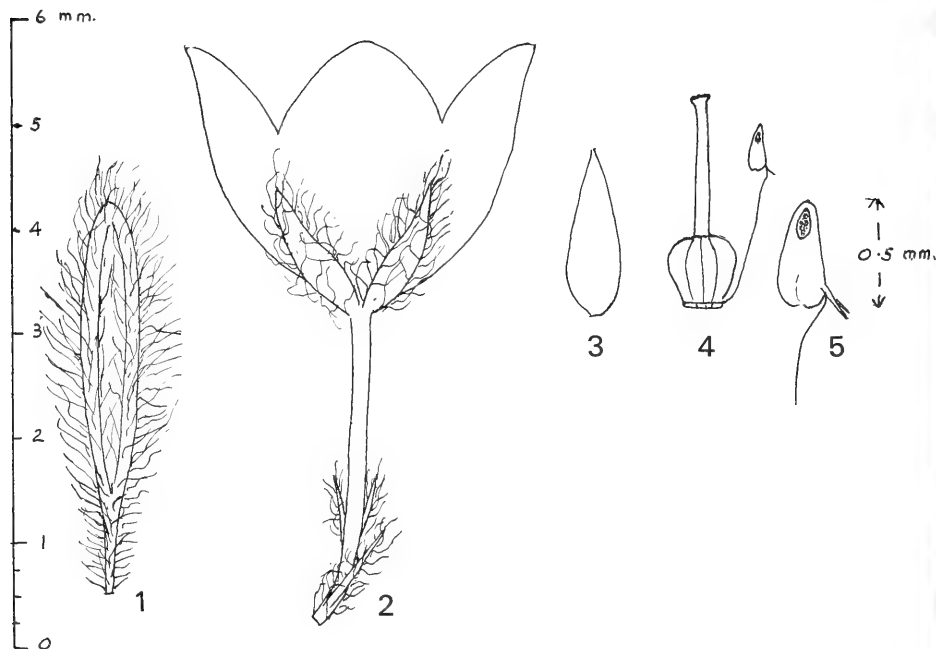


FIG. 7.

*Erica intricata* 1. leaf; 2. flower; 3. sepal without the hairs; 4. gynoecium and stamen; 5. anther, side view.

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#### ACKNOWLEDGEMENTS

In addition to the acknowledgements on the individual species the author wishes to thank the curators of the Bolus and the Compton Herbaria for allowing him to make use of the facilities therein and in particular for the assistance received from Miss Esterhuysen at the former with the specimens that she collected.

#### CORRIGENDA

##### A NEW ERICA FROM THE SOUTHERN CAPE . . .

J.S.A.B., Vol. 33, Part 3, p. 179, line 24: for *blanda* read *alba*.

p. 183, line 7 from bottom of the page,  
insert heading:

*ERICA COCCINEA* L. AND VARIETIES



# 'n ANATOMIESE EN ONTOGENETIESE STUDIE VAN DIE WORTELS VAN SUID-AFRIKAANSE LILIACEAE:

## II. DIE ANATOMIE VAN DIE VOLWASSE BYWORTELS†

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\*'n Verkorte weergawe van 'n proefskrif goedgekeur vir die graad van Doktor in die Natuurwetenskappe aan die Universiteit van Stellenbosch, September 1965.

### ABSTRACT

The anatomy of the stem-borne adventitious roots at the conclusion of primary growth, as seen in cross sections, was investigated in the present study. Roots with a prolonged life showed the most interesting and varying anatomical features in some of the species, e.g. the presence of velamen, a multiple exodermis, a more or less sclerozed cortex and pith and the development of secondary tissues in woody types.

Altogether 35 species, belonging to the seven sub-families (Krause, 1930) occurring in South Africa, were investigated.

According to Hutchinson (1959, p. 640) *Agapanthus* is a link between the Liliaceae and the Amaryllidaceae. The anatomy of the roots of four species of the Amaryllidaceae was investigated and compared with that of *Agapanthus* spp. Their anatomical features are more or less alike.

### INLEIDING

In die huidige studie is die anatomie van die bywortels, aan die einde van primêre ontwikkeling, van 35 Suid-Afrikaanse soorte van die Liliaceae ondersoek. Min navorsing is tot op datum hieroor gedoen.

Die studie is ook onderneem met die oog op die navorsing oor die vergelykende anatomie van die monokotiele wat op die oomblik deur dr. C. R. Metcalfe by die Jodrell Laboratorium te Kew, onderneem word.

Metcalf (1963) skryf soos volg in verband met die wortelstruktuur: "It seems likely that root structure will remain of limited taxonomic interest because it so often turns out that monocotyledons of diverse affinities are alike in having

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† Aanvaar vir publikasie 23 Januarie 1968.

a polyarch stele surrounded by a well-developed endodermis, xylem marked by a circle of conspicuously large metaxylem vessels alternating with phloem strands, the ground tissue of the stele being more or less sclerozed in proportion to the 'woodiness' of the species concerned". Die huidige studie behoort dus ook opgevolg te word deur navorsing oor die anatomie van die stingels en blare van die Liliaceae. Eers dan mag dit moontlik wees om anatomiese kenmerke vir klassifikasiedoeleindes te gebruik vir hierdie familie.

#### 'N OORSIG VAN DIE BESKIKBARE LITERATUUR

Schulze (1893) maak 'n vergelykende anatomiese studie van „der Liliaceen, Haemodoraceen, Hypoxidoideen und Veloziazeen". Ongelukkig word die wortelanatomie nie bespreek nie, maar daar word nietemin vasgestel dat sekere anatomiese kenmerke tog van waarde is vir sistematiese doeleindes.

Oor die ontwikkeling van die sentrale silinder by die Araceae en die Liliaceae lewer Chrysler (1904) 'n baie beknopte en onvolledige oorsig.

By *Asparagus officinalis* vind Blasberg (1932) dat die wande van die buitenste paar sellae van die skors verdik en verkurk is. As sulks vorm dit 'n uitstekende beskermingslaag.

Breyer-Brandwijk (1934) beskryf die wortelanatomie van *Gloriosa virescens*, *Bowiea volubilis* en *Scilla lanceaefolia*, soos gesien in dwarsnee, en stel vas dat nie net die „hipodermis" verhoof of verkurk is nie, maar ook die epidermis. (Dit is die enigste Suid-Afrikaanse publikasie oor die wortelanatomie van die Liliaceae).

Oor die perforasieplate in die xileem van die wortels van die Liliaceae, skryf Cheadle (1942) soos volg: "The roots of this family generally have scalariform plates in the vessels, but *Aloe*, *Anthericum*, *Asparagus*, *Chlorophytum*, *Kniphofia* and *Ornithogalum* generally have simple plates, with a few scalariform plates in the early-matured metaxylem in some cases".

Van Fleet (1950) stel vas dat bande van Caspary soms voorkom in die „hipodermis" van *Smilax*- en *Allium*-soorte.

#### MATERIAAL EN METODES

Daar is gebruik gemaak van bywortels in die ondersoek aangesien die kiemworteltjie by die Liliaceae baie vroeg afsterf en die wortelstelsel gevolglik advertief uit die stingel ontwikkel. Sien verder Pienaar (1968).

In die ondersoek is gebruik gemaak van hand- en rotasiemikrotroomsneë.

Handsneë het verreweg die beste resultate gelever in dié materiaal waar dit moontlik was om hierdie metode aan te wend. Ná fiksering in F.A.A. (Johansen, 1940), is die materiaal in lopende kraanwater vir ongeveer twee uur gewas. Die sneë is gesny, uitgesoek en gekleur in Delafield se haematoksilien en

II. Die Anatomie van die Volwasse Bywortels

safranien, en safranien alleen. Die sneë is gemonteer in gliserien of in gliserien-jellie.

In hierdie sneë is die selle baie minder onderhewig aan die nadelige invloed van 'n langdurige dehidreringsproses en ander chemiese stowwe. Die protoplasmatiese inhoud van die selle en die stippels in die selwande bly besonder duidelik. Hierdie tydelike preparate is gou om te maak en hou lank genoeg vir 'n deeglike ondersoek, beskrywing, die neem van foto's en die maak van sketse.

Dieselfde metode as in die vorige ondersoek (Pienaar, 1968) is aangewend vir die maak van permanente preparate.

Jeffrey se maserasiemetode (Johansen, 1940) met 10% chroomsuur en 10% salpetersuur is gebruik.

Die gewone histochemiese reagentie is gebruik vir die toets van kurkstof, lignien, setmeel, sellulose en kalsiumoksalaat. Vir die toets van slymsuur is die pirrol-toets gebruik. Die wortel word geweek in gekonsentreerde ammoniakoplossing vir 20 tot 30 minute—om die ammoniumsout van die slymsuur te vorm, naamlik  $\text{NH}_4\text{OOC}(\text{CHOH})_4\text{COONH}_4$ . Hierna word die wortel verhit in 'n proefbuis totdat dit droog is. Alle ammoniakdampe word uit die buis geblaas. 'n Stukkie hout word gedoop in gekonsentreerde soutsuur en dan by die bek van die buis gehou terwyl die wortel weer verhit word. Die ammoniumsout breek op en dampe van pirrol kom vry wat die hout pers-rooi kleur. Hierdie toets toon nie aan in watter selle die slym voorkom nie. Vir tannien is K-dichroomaat gebruik en vir kallose anilienblou.

Mikrofoto's is geneem met 'n Wild-plaatkamera (6.4 cm. x 8.9 cm.). Sommige van die sketse is gemaak met behulp van 'n Wild-tekenbuis.

ONDERSOEK

Die volgende soorte is ondersoek.

<i>Sub-familie</i>	<i>Naam van die soort</i>
A. Melanthioideae	Gloriosa superba Linn. Dipidax triquetra (L.f.) Baker Bulbinella robusta Kunth Bulbine caulescens Linn.
B. Asphodeloideae	B. asphodeloides R. & S. Anthericum galpinii Baker Chlorophytum capense (L.) Voss Eriospermum pumilum Salter Kniphofia ensifolia Baker Haworthia tessellata Haw. H. truncata Schönl. Gasteria pillansii Kensit Aloe arborescens Mill. A. ciliaris Haw.
C. Allioideae	Agapanthus campanulatus Leighton A. caulescens Sprenger

	A. comptonii Leighton
	A. inapertus Beauv.
	A. orientalis Leighton
	A. pendulus Leighton
	A. praecox Willd.
	Tulbaghia alliacea L.f.
	Allium rotundum Linn.
D. Scilloideae	Albuca aurea Jacq.
	Galtonia candicans Decne.
	Scilla natalensis Planch.
	Eucomis nana Ait.
	Ornithogalum hispidum Hornem.
	Pseudogaltonia clavata Phillips
	Veltheimia deasii Barnes
	Lachenalia glaucina Jacq. var. pallida
E. Dracaenoideae	Dracaena hookeriana K.Koch
	Sansevieria longiflora Sims
F. Asparagoideae	Asparagus compactus Salter
G. Smilacoideae	Smilax kraussiana Meissn.

Volgens Hutchinson (1959, p. 640) is *Agapanthus* 'n skakel tussen die Liliaceae en die Amaryllidaceae. Die wortelanatomie van 'n paar soorte van die Amaryllidaceae is ondersoek en vergelyk met die wortelanatomie van *Agapanthus*-soorte, om vas te stel of daar in hierdie opsig ooreenkomste en/of noemenswaardige verskille voorkom tussen verteenwoordigers van die twee families. Die volgende soorte van die Amaryllidaceae is ondersoek:

*Clivia caulescens* Dyer, *Boophone disticha* (L.f.)Herb., *B. guttata* (L.) Herb. en *Haemanthus albiflos* Jacq.

#### 'N OPSOMMING VAN DIE ALGEMENE ANATOMIESE KENMERKE VAN DIE ONDER- SOEKTE SOORTE

##### Epidermis

Indien aanwesig is dit een sellaaag breed. Die selle besit 'n protoplasmatiese inhoud en geen trichoblaste (spesiale haarvormende epidermisselle) kon by enige van die soorte waargeneem word nie. By sommige meerjarige wortels is die buitenste selwande effens verdik en verkurk, bv. by *Kniphofia ensifolia*. Dit stem ooreen met die soorte wat deur Breyer-Brandwijk (1934) ondersoek is.

##### Velamen

'n Velamen, wat meer as een sellaaag breed is, kom voor by *Bulbinella robusta*, *Asparagus compactus* en al sewe die ondersoekte *Agapanthus*-soorte. Besonderhede oor die ontogenie en morfologie van die velamen sal in 'n volgende publikasie verskyn.

##### Skors

Behalwe by *Gloriosa superba*, differensieer die buitenste sellaaag van die skors as 'n eksodermis wat by baie soorte bestaan uit groot selle en kleiner deurlaat-selle (*Kniphofia ensifolia*, fig. 1). In 'n paar soorte is die eksodermis meer as een

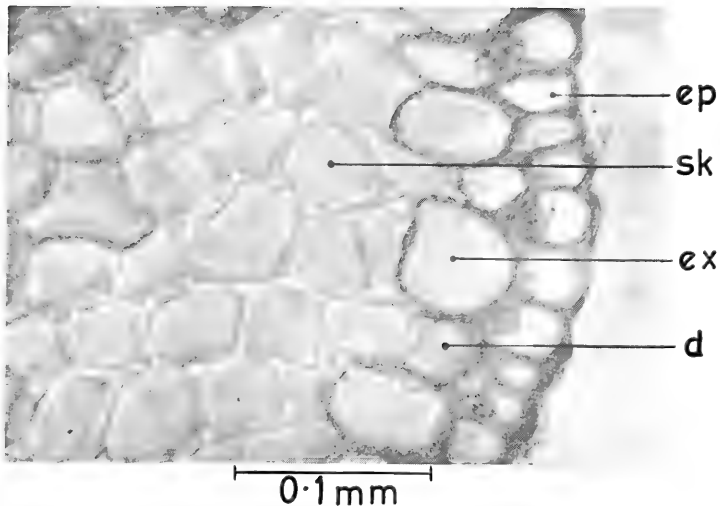


FIG. 1.

*Kniphofia ensifolia*. D.S. van die buitenste gedeelte van die jong wortel: d, deurlaatsel in die eksodermis met 'n protoplasmatische inhoud; ep, epidermis met sitoplasma en kerne, en die buitenste tangensiale wande verdik; ex, eksodermis; sk, skorsparenchiem.

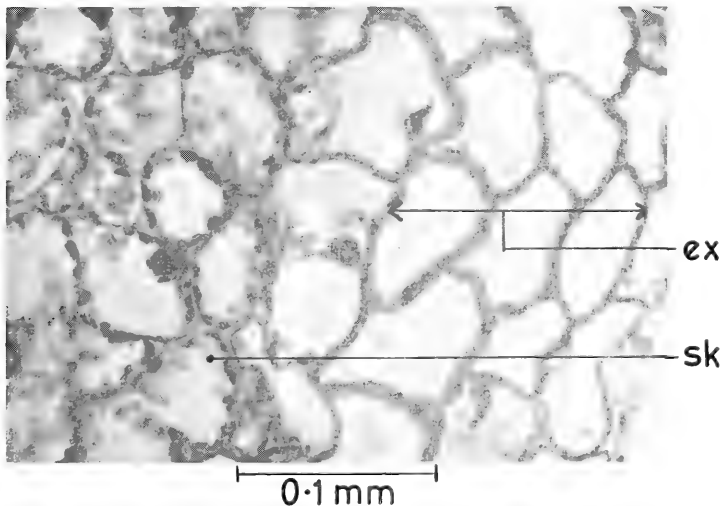


FIG. 2.

*Bulbine caulescens*. D.S. van 'n gedeelte van die buiteskors: ex, veellagige eksodermis met effens dikwandige, verkurkte selle; sk, parenchimatiese skorselle met chloroplaste en intersellulêre ruimtes.

sellaag breed en is die wande van die selle effens verdik en verkurk (*Bulbine caulescens*, fig. 2). Die verkurking kon waargeneem word as 'n bepaalde suberienlamella. Breyer-Brandwijk (1934) stel vas dat 'n verkurking plaasvind in die „hipodermis” van die soorte wat hy ondersoek het. In die huidige studie word die term eksodermis verkies bo hipodermis (vgl. ook Esau, 1953, p. 481). Besonderhede oor die ontogenie en die morfologie van die eksodermis verskyn in 'n volgende publikasie.

Die grootste gedeelte van die skors bestaan uit dunwandige parenchiemselle met 'n protoplasmatiese inhoud en intersellulêre ruimtes. Verhoute parenchiemselle mag voorkom in die skors. By *Aloe arborescens* en *A. ciliaris* kom hierdie selle verspreid in die skors voor asook, soos by sommige ander soorte, in 'n

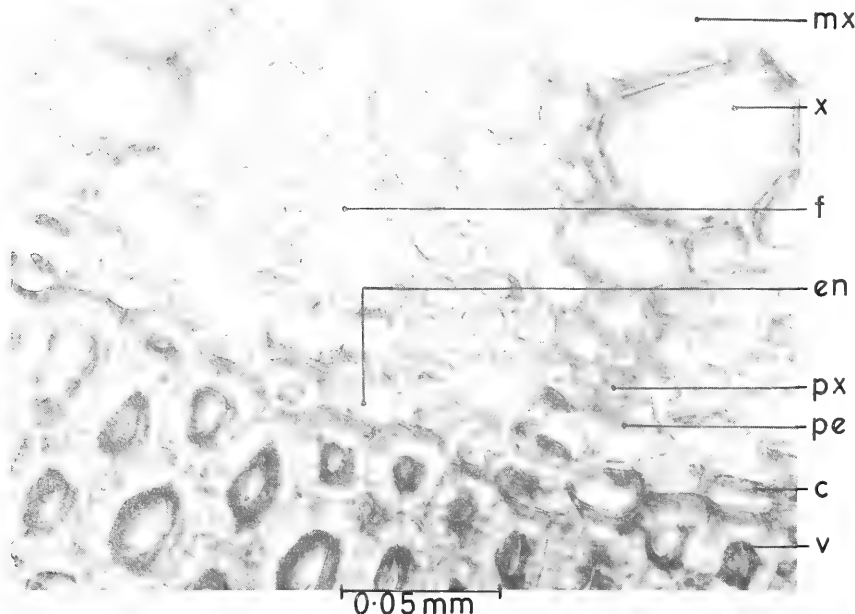


FIG. 3.

*Kniphofia ensifolia*. D.S. van 'n gedeelte van die sentrale silinder en die binneskors: c, band van Caspary; en, endodermis met dikwandige selle teenoor die floëm en dunwandige selle teenoor die protoxileëm; f, floëm, met die protofloëmelemente effens verdruk; mx, dunwandige metaxileëmvat; pe, perisikel; px, protoxileëm; v, dikwandige, verhoute parenchiemselle van die skors—let op die protoplasmatiese inhoud, eenvoudige stippels en die klein intersellulêre ruimtes; x, dikwandige metaxileëmvat.

aaenelopende mantel, een of meer sellae breed, om die endodermis, bv. *Kniphofia ensifolia* (fig. 3), *Bulbine caulescens*, *Smilax kraussiana* en *Asparagus compactus*. Hierdie selle kan sterk dikwandig wees en besit talryke eenvoudige vertakte en onvertakte stippels. 'n Protoplasmatiese inhoud is waargeneem in sommige van hierdie selle.

Die binneste laag selle van die skors differensieer as 'n endodermis. Drie strukturele toestande van ontwikkeling is in hierdie selle waargeneem:

primêr: met bande van Caspary in die radiale selwande,

sekondêr: met 'n suberienlamella wat die selwand aan die binnekant van die sel bedek, en

tersiêr: met die selwande verdik en verhout.

In baie gevalle is die verdikking beperk tot die binneste tangensiale en die radiale wande. Aldrie bogenoemde toestande kan voorkom in dieselfde dwars-snee (vgl. *Kniphofia ensifolia*, fig. 3). Waar die selle dikwandig is, besit hulle gewoonlik eenvoudige stippels en/of kom daar dunwandige deurlaatselle voor wat in die bg. primêre toestand bly. Hierdie deurlaatselle kom gewoonlik voor teenoor die protoxileemgroepe. Die endodermis selle besit 'n protoplasmatiese inhoud.

### Perisikel

In meeste van die ondersoekte soorte bestaan dit uit 'n enkele laag dunwandige parenchiemselle met 'n protoplasmatiese inhoud, behalwe by *Smilax kraussiana* (fig. 4) waar dit drie tot ses lae breed is. In sommige soorte is die selwande effens verdik en verhout, bv. *Asparagus compactus*.

Die perisikel sluit aan by die grondweefsel van die stele waarin die xileem- en floëemgroepe lê.

### Xileem

Die aantal protoxileemgroepe wat voorkom in die verskillende soorte varieer aansienlik. So bv. kom daar by *Galtonia candicans* slegs sowat vyf groepies voor teenoor die sowat 30 — 36 by *Smilax kraussiana* en die sowat 50 by *Aloe arborecens*. Die aantal protoxileemgroepe kan varieer in verskillende wortels van dieselfde soort (vgl. Foster, 1949) en selfs in dieselfde wortel, bv. by *Haworthia truncata*. Hierdie bevinding is in ooreenstemming met Esau (1953, p. 485) se verklaring: "The number of protoxylem poles is in general characteristic in the different large groups of plants, but it is not stable. Like the presence or absence of pith, it is related to the diameter of the vascular cylinder. If the diameter is long, the number of poles is larger, and pith is more likely to be present than in roots with narrow vascular cores. Such variations may occur in the same

plant. Frequently the number of xylem strands is higher in the proximal (basal) end of a given root than in its distal (apical) end, but the change may occur in the opposite direction as well".

Daar is 'n geleidelike oorgang van proto- na metaxileem. In hierdie ondersoek word ring- en spiraalvate beskou as elemente van die protoxileem en leer-, net- en stippelvate beskou as elemente van die metaxileem (vgl. Esau, 1953, p. 239).

#### i. Protoxileem

In 'n dwarsdeursnee vertoon die elemente baie kleiner in deursnee as dié van die metaxileem. In gemasereerde materiaal van 'n hele aantal soorte, is slegs houtvate met spiraalvormige verdikkings waargeneem.

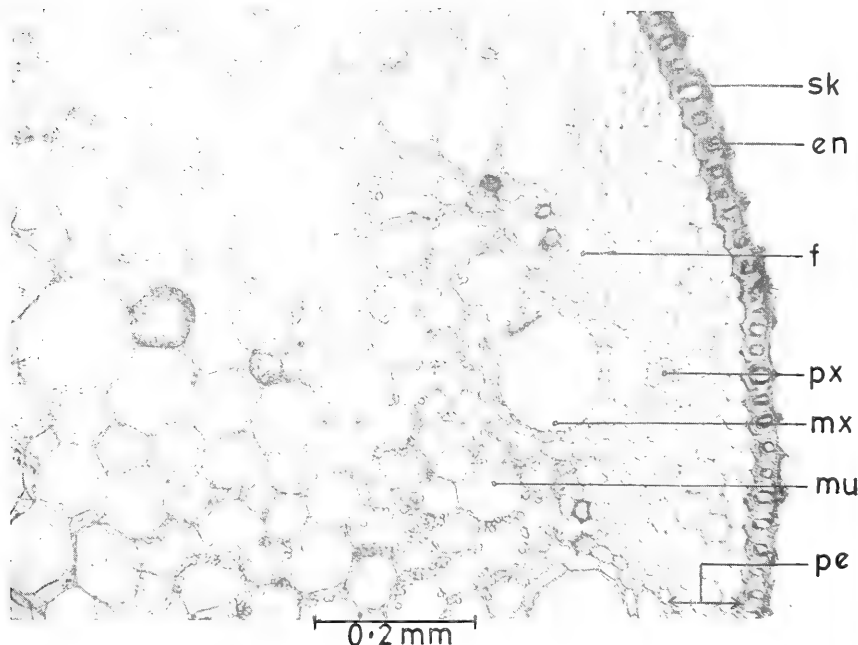


FIG. 4.

*Smilax kraussiana*. D.S. van 'n gedeelte van die sentrale silinder: en, endodermis met U-vormig verdikte wande; f, floëem; mu, murgparenchium met styselkorrels; mx, metaxileemvat; pe, meerlagige perisikel; px, protoxileem; sk, oorblyfsels van die skors. Let op die donker gekleurde sekreet in die murg.



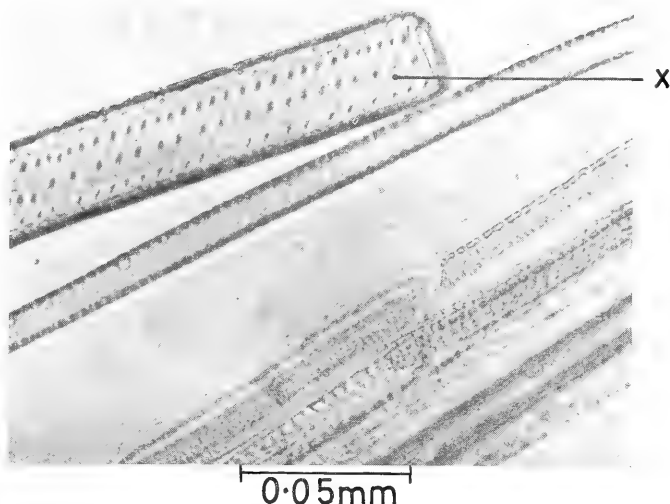


FIG. 5.

*Asparagus compactus*. Gemasereerde materiaal van die wortel: x, 'n gedeelte van 'n stippelvate. Let op die eenvoudige perforasielate wat haaks lê met die lengtewande.

## ii. Metaxileem

Leer-, net- en stippelvate is waargeneem by sommige van die ondersoekte soorte, bv. *Asparagus compactus* (fig. 5), *Bulbinella robusta* en *Veltheimia deasii*. Variasies in die tipe van verdikking in dieselfde element is ook waargeneem, bv. by *Asparagus compactus* 'n leer-stippelvate (leervormige verdikkings aan die een kant en stippels aan die ander kant) en by *Bulbinella robusta* 'n spiraal-leervate (fig. 6). Die stippels is in meeste gevalle spleet- en/of kruisspleet-hofstippels. Die metaxileemvate is nie altyd in samehang met die protoxileemvate nie maar lê soms los, bv. by *Veltheimia deasii*.

## iii. Perforasielate

Die eindwande in meeste van die houtvate is haaks geleë en nie skuins met die lengte-as van die vate nie. Die oorgrote meerderheid van die vate besit eenvoudige perforasielate. Die hele eindwand is geperforeer met die gevolg dat stertjies afwesig is. Leervormige perforasielate is waargeneem in die eerste metaxileemvate van sommige soorte. Hierdie bevindings is in ooreenstemming met dié van Cheadle (1942). By *Aloe arborescens* is 'n stippelvate waargeneem met 'n eenvoudige perforasielate in die sywand (fig. 7).

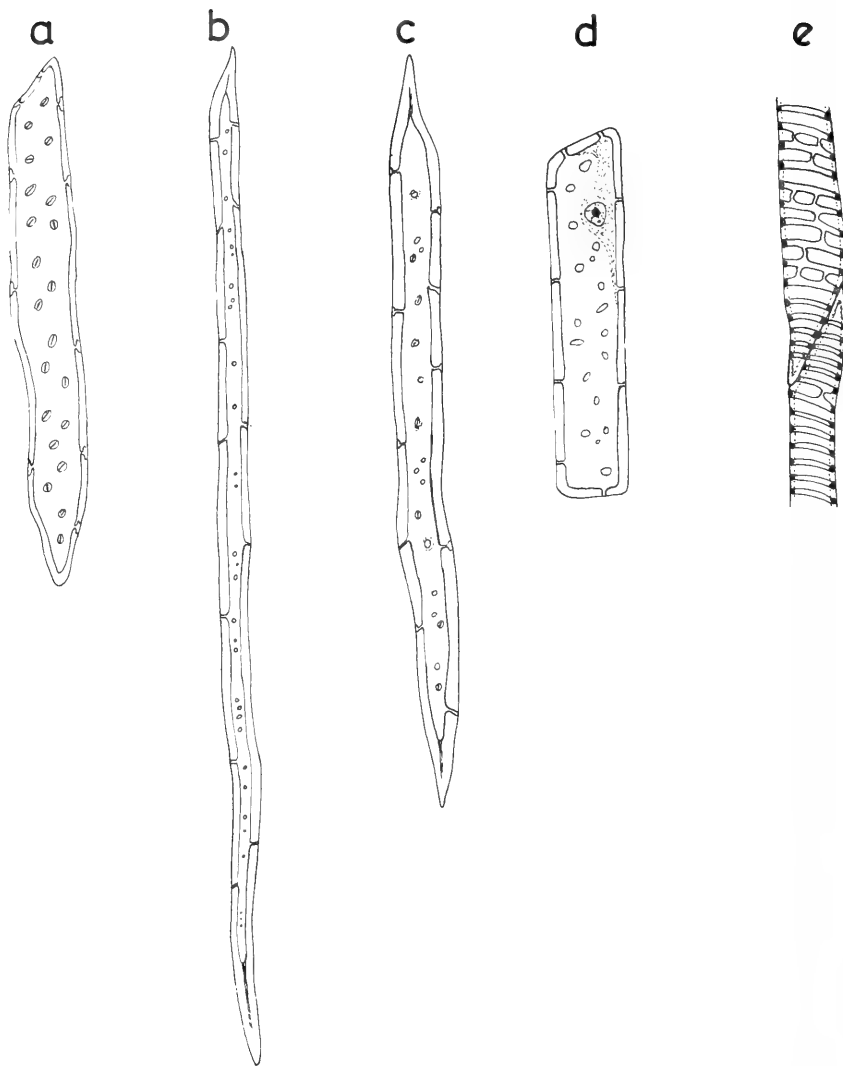


FIG. 6.

*Asparagus compactus*. Sketse van gemasereerde materiaal van die sentrale silinder van die wortel: a, tracheïed; b, vesel; c, veseltracheïed; d, dikwandige, verhoute parenchiemsel.

*Bulbinella robusta*. e, gedeeltes van twee spiraalleervate in die wortel.

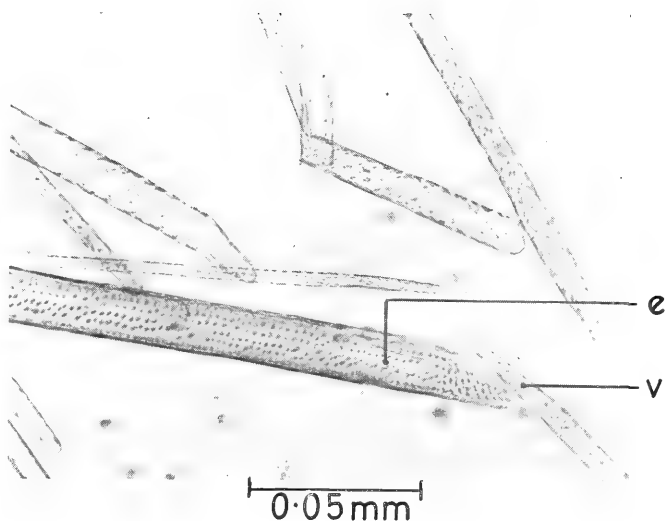


FIG. 7.

*Aloe arborescens*. Gemasereerde materiaal van die sentrale silinder van die wortel: e, eenvoudige persiforatieplaat in die sywand van 'n stipevat; v, vesel.

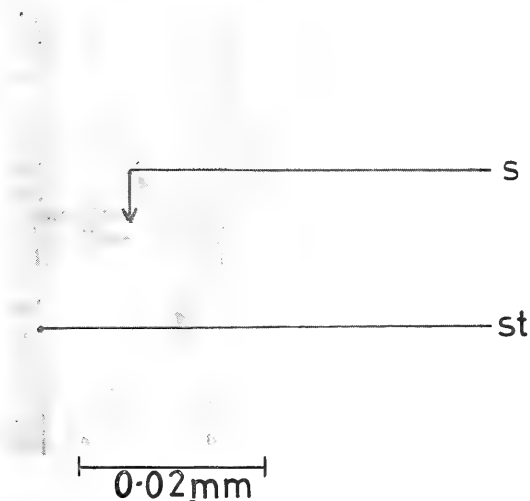


FIG. 8.

*Asparagus compactus*. 'n Septum en 'n gedeelte van die lengte-wand van 'n gesepeteerde vesel: s, septum; st, eenvoudige stipe. Dis duidelik dat die septum slegs kontak maak met die sekondêre wandlae van die lengte-wand van die vesel.

'n Verskeidenheid van vesels, gesepteerde vesels, veseltracheïede en enkele tracheïede is in die xileem van 'n paar ondersoekte soorte waargeneem. Hierdie selle vertoon 'n groot variasie in grootte, struktuur en inhoud. In baie gevalle besit die vesels, gesepteerde vesels en die veseltracheïede 'n duidelike protoplasmatiese inhoud. Vesels met een skerp en een stomp punt is waargeneem. Die veseltracheïede besit 'n groot aantal gereduseerde hofstippels, bv. by *Bulbinella robusta* (fig. 10). Fig. 8 illustreer 'n tipiese gesepteerde vesel in *Asparagus compactus*. Die septum maak nie kontak met die vertikaal georiënteerde primêre wande van die moedersel nie maar slegs met die sekondêre wandlae (vgl. Spackman en Swamy, 1949).

### Floëem

Die aantal floëemgroepe stem ooreen met die aantal protoxileemgroepe en hulle bestaan uit dunwandige sifvate, enkele begeleidendes selle en parenchiemselle. In dwarsnee vertoon die sifvate oënskynlik geen plasmainhoud nie, terwyl dit in die omliggende parenchiemselle sigbaar is. Elke floëemgroep besit sowat 3—6 sifvate en die groep word begrens deur 'n mantel van parenchiemselle waarvan die wande bietjie dikker is as dié van die sifvate en in sommige gevalle ook effens verhout is.

Die sifplate is eenvoudig en die eindwande is min of meer dwars geleë. Sifareas op die lengtewande, tussen aangrensende sifvaatelemente, is nie waargeneem nie.

### Weefsels van die murg

#### *Parenchium*

In baie soorte bestaan die murg net uit dun- en/of effens dikwandige parenchiemselle met 'n protoplasmatiese inhoud, talryke eenvoudige stippels en intersellulêre ruimtes. In sommige gevalle, bv. *Asparagus compactus*, is die parenchiemselle sterk dikwandig en verhout. Die eindwande van sommige van hierdie selle is netvormig verdik (fig. 9). Dit wou voorkom of hierdie dwarswande nie so baie verhout is soos die ander selwande nie. Met safranien is hulle ligrooi gekleur teenoor die helderrooi kleur van die ander selwande en is die dele tussen die netvormige verdikkings kleurloos. Of hierdie selle moontlik klein vaatelemente met netvormige perforasieplate is, kon nie met sekerheid vasgestel word nie. In 'n maseraat van die materiaal kon xileemvate slegs met eenvoudige perforasieplate en enkeles met leervormige perforasieplate waargeneem word.

Verspreide metaxileemvate kom in sommige gevalle in die sentrale gedeelte van die wortel voor, bv. by *Albuca aurea*, *Scilla natalensis* en *Veltheimia deasii*, aldrie behorende tot die Scilloideae, en ook by 'n paar Agapanthus-soorte. Hierdie houtvate lê gebed in 'n parenchimatiese weefsel wat dun- of dikwandig mag wees.

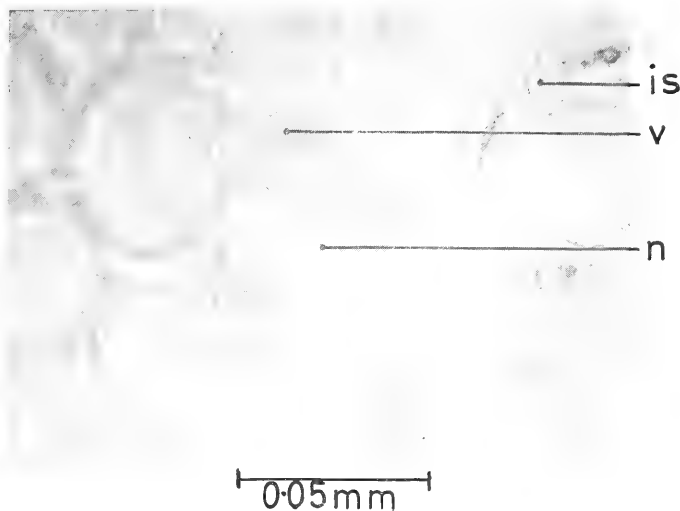


FIG. 9.

*Asparagus compactus*. D.S. van 'n gedeelte van die sentrale silinder van die wortel: is, intersellulêre ruimte; n, netvormig verdikte dwarswand van 'n dikwandige, verhoue parenchiemsel; v, dikwandige, verhoue sel met 'n protoplasmatische inhoud.

By *Bulbinella robusta* bestaan die sentrale gedeelte van die wortel uit sterk dikwandige, verhoue veseltracheïede met talryke gereduseerde hofstippels en enkele vesels met eenvoudige stippels. Hierdie selle kan waarskynlik beskou word as deel van die metaxileem (fig. 10).

#### Selinsluitinge

Styselkorrels kan voorkom in die parenchimatiese skorselle, bv. by *Bulbinella robusta* en in die parenchimatiese murgselle, bv. by *Smilax kraussiana* (fig. 4). In meeste van die soorte is stysel egter afwesig.

In die wortels, wat op een of ander manier aan lig blootgestel is, kom chloroplaste dikwels in die parenchimatiese skorselle voor, bv. by *Bulbine caulescens* (fig. 2) en baie van die *Agapanthus* spp.

Tannien kom voor in sommige selle van die skors van *Eriospermum pumilum*.

Rafides van kalsiumoksalaat kom voor in die parenchimatiese skorselle en in die parenchimatiese murgselle van baie van die soorte, bv. by die *Agapanthus* spp., *Asparagus compactus* en *Bulbinella robusta*. Die rafides kom voor in bundels en is altyd ewewydig met die lengteas van die wortel gerangskik. In

lengtesneë is waargeneem dat die rafidebundels in selle kan voorkom wat baie naby aan die apikale meristeem geleë is.

Slym kom veral in die wortels van die *Agapanthus* spp. voor.

Verspreide selle met 'n nog onbekende sekreet, kom voor in die parenchimatiese murgselle van *Smilax kraussiana* (fig. 4).

*Slymselle, Slym en Rafides* bv. by *Agapanthus praecox* (fig. 11).

Die slymselle kon slegs in die dwarsneë uitgeken word aan hulle besonder opvallende strukturele voorkoms tussen die ander parenchiemselle, veral in die skors. Die selinhoud is korrelagtig en die dun selwande buig teenoor die inter-sellulêre ruimtes na binne in die rigting van die sellumen. Geen chemiese toets om die aanwesigheid van slym in bepaalde selle aan te toon, kon in die literatuur opgespoor word nie.

Oor slymselle, slymkanale en rafidesakke by die *Palmae*, skryf Tomlinson (1961) soos volg: "Mucilage canals, which are apparently modified raphide-sacs,

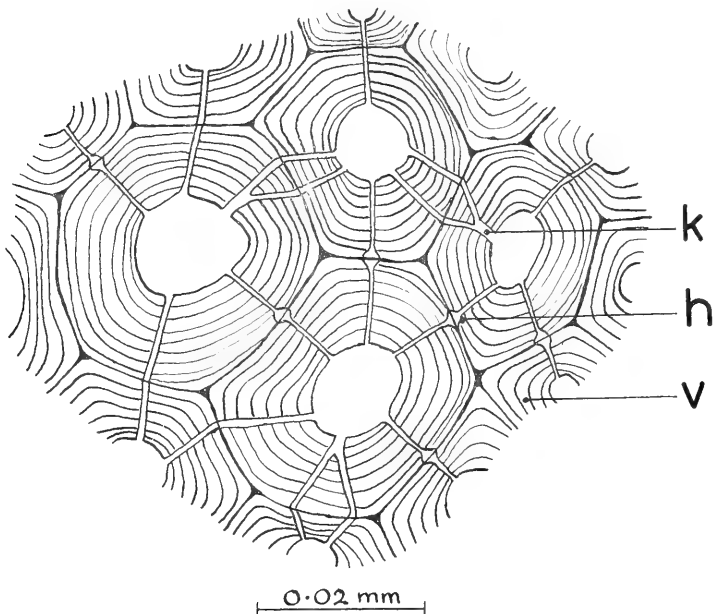


FIG. 10.

*Bulbinella robusta*. Vesels en veseltracheiede in die sentrale silinder van die wortel. Let op die eenvoudige vertakte stipfelkanale (k), die gereduseerde hofstippels (h) en die verdikkingslae (v) in die wande.

are sometimes abundant, especially in the root. They consist of elongated cylindrical cells each of which contains a raphide cluster and mucilaginous material. Raphide-sacs are normally idioblastic although sometimes they are arranged in distinct files. When these files are long and continuous there is a transition to the mucilage canals". Met ander woorde, die rafides word geassosieer met die slymselle en slymkanale by die *Palmae*.

In lengtesneë van *Agapanthus praecox* is waargeneem dat die rafidebundels in sommige gevalle in alleenstaande selle voorkom en in ander gevalle vorm

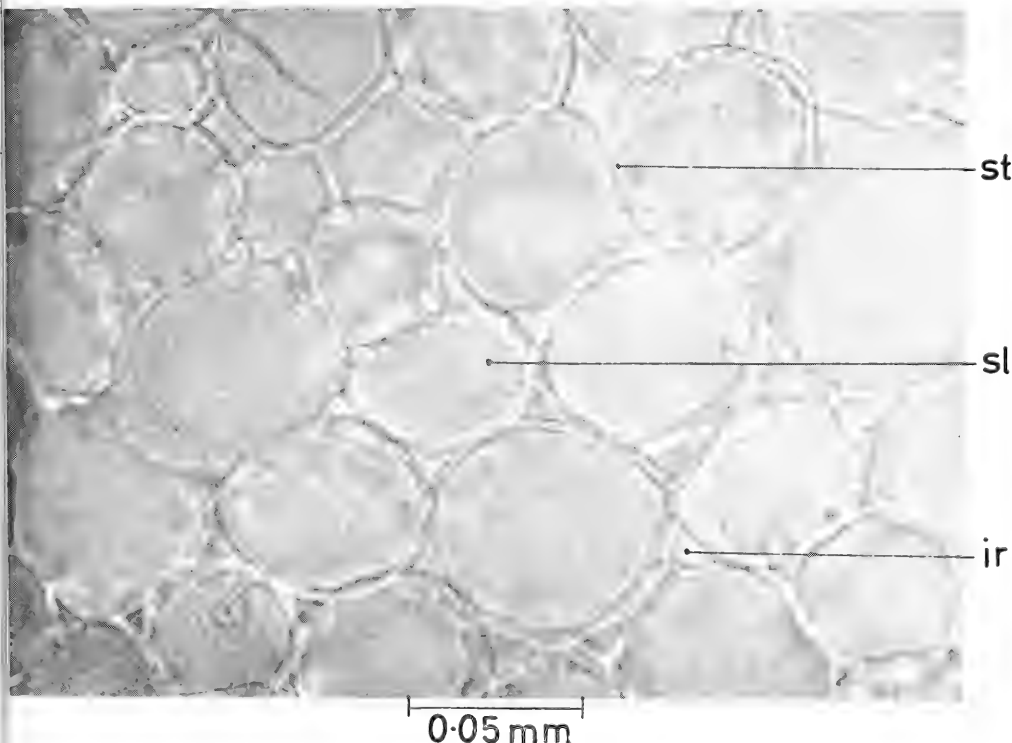


FIG. 11.

*Agapanthus praecox*. D.S. van 'n gedeelte van die skors met slymselle (sl) tussen die dunwandige parenchiemselle. Let op die korrelrige inhoud van die slymselle. Eenvoudige stippels (st) in die selwande en die intersellulêre ruimtes (ir) is duidelik te sien.

hierdie selle lang lengterye. Maar of hierdie selle ook die slymbevattende selle is, is nie duidelik nie. Die rafideselle is in sommige gevalle langer en nouer as die aangrensende parenchiemselle.

### Verkurkte selwande en die deurlaat van water

Suberien kom voor in die selwande van sommige eksodermis- en endodermiselle. Volgens ouere opvattinge sal hierdie selwande dus die deurlaat van water verhinder. Kramer (1946) en Addoms (1946) wys egter daarop dat wortels, waarvan die selwande verkurk is, tog water opneem en in sommige gevalle selfs genoeg om verlepning by dié plante te voorkom.

In die huidige ondersoek is vasgestel dat eenvoudige stippels in die verdikte, verkurkte selwande van die eksodermis- en endodermiselle kan voorkom, bv. by *Kniphofia ensifolia* en *Bulbinella robusta*. Die endodermis besit in baie gevalle egter dunwandige deurlaatselle, veral teenoor die xileemgroepe.

### DIE BESONDERE BOU VAN MEERJARIGE WORTELS

By baie van die ondersoekte plante funksioneer die wortels vir meer as een groeiseisoen. Hierdie wortels ondergaan gewoonlik strukturele wysiginge wat blykbaar toegespits is op beskerming en versterking.

### Besondere wysiginge

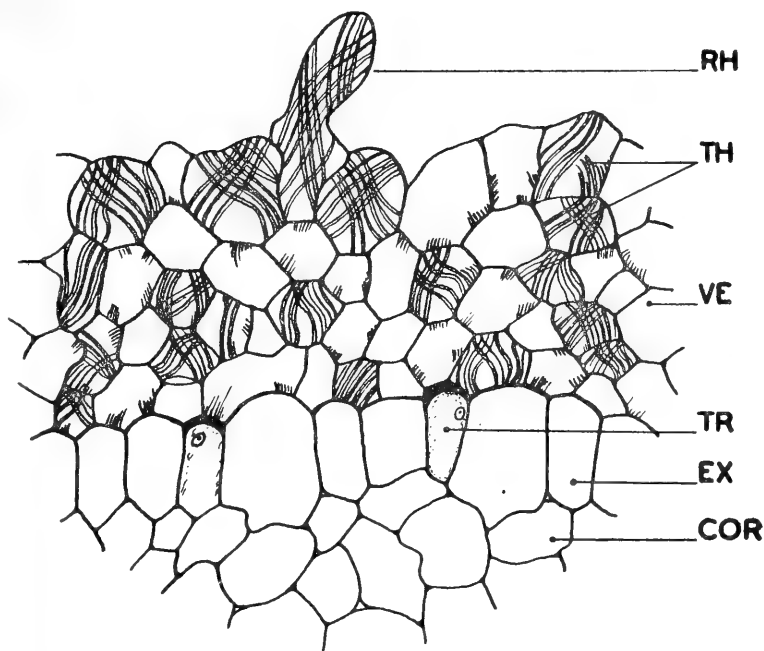
#### A. Primêre weefsels

1. Die ontwikkeling van 'n velamen, bv. by die *Agapanthus* spp., *Bulbinella robusta* en *Asparagus compactus*.
2. Die ontwikkeling van 'n meerlagige, verdikte en verkurkte eksodermis, bv. by *Asparagus compactus*, *Bulbine caulescens*, *Bulbinella robusta* en *Dracaena hookeriana*.
3. Die ontstaan van dikwandige, verhoude parenchiemselle in die skors. In sommige gevalle kom hierdie selle verspreid voor, bv. by *Aloe ciliaris*. In ander gevalle vorm hulle 'n meganiese mantel (een of meer sellae breed) rondom die endodermis, bv. by *Kniphofia ensifolia*, *Bulbine caulescens* en *Asparagus compactus*.
4. By *Smilax kraussiana* verdwyn die skorsgedeelte behalwe vir die endodermiselle, waarvan die wande sterk verdik en verhout is.
5. Die murggedeelte kan geheel of gedeeltelik sklerenchimaties word, bv. by *Asparagus compactus*, *Bulbinella robusta*, *Agapanthus orientalis* en *A. inapertus*.

#### B. Sekondêre weefsels

Besonderhede oor die ontwikkeling van periderm by enkele soorte en „diffuse sekondêre diktegroei” by *Aloe arborescens* sal in 'n latere publikasie verskyn.





0.1 MM.

FIG. 12.

*Clivia caulescens*. D.S. van die buitedeel van die wortel: cor, skors; ex, eksodermis; rh, wortelhaar; th, spiraalvormige wandverdikkings; tr, deurlaatsel met verdikte buitenste tangensiale wand en 'n protoplasmatiese inhoud; ve, velamen. (Nageteken uit: Pienaar, Ongepubliseer, 1947).

#### 'N KORT VERGELYKING TUSSEN DIE WORTELANATOMIE VAN AGAPANTHUS-SOORTE EN DIÉ VAN ENKELE SOORTE VAN DIE AMARYLLIDACEAE

Volgens Hutchinson (1959, p. 640) is *Agapanthus* 'n skakel tussen die *Liliaceae* en die *Amaryllidaceae*. Om hierdie rede word, in die huidige studie, die wortelanatomie van 'n paar soorte van die *Amaryllidaceae* ondersoek om te vergelyk hoe dit moontlik ooreenstem of verskil met dié van *Agapanthus*-soorte.

Die volgende soorte van die Amaryllidaceae is ondersoek: *Clivia caulescens*, *Haemanthus albiflos*, *Boophone disticha* en *B. guttata*. Volgens Pax en Hoffmann (1930) behoort hulle tot die sub-familie Amaryllidoideae, tribus Amaryllideae en die sub-tribus Haemanthinae. Hutchinson (1959) beskou hierdie drie genera as betreklik primitief. (Laasgenoemde twee soorte het skrywer anatomies beskrywe vir 'n verhandeling vir die M.Sc.-graad aan die Universiteit van Pretoria in 1947. Fig. 12 en 13 is geneem uit hierdie verhandeling).

Die wortels is meerjarig en sowat 3—6 mm. in deursnee.

#### Velamen

Soos by die *Agapanthus*-soorte vorm 'n velamen die beskermende mantel van die wortel. Behalwe by *Haemanthus albiflos* is die velamen meer as een

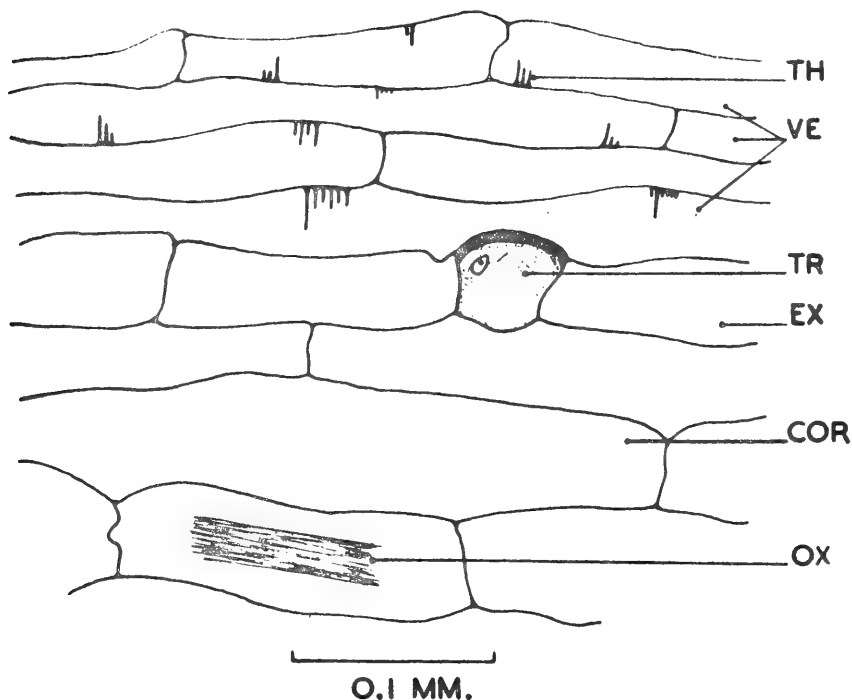


FIG. 13.

*Boophone disticha*. R.L.S. van die buitedeel van die wortel: cor, skors; ex, eksodermis; ox, rafides van kalsiumoksalaat; th, penvormige wandverdikkings in die velamenselle; tr, deurlaatsel met 'n protoplasmatische inhoud en 'n verdikte buitenste tangensiale wand; ve, velamen. (Nageteken uit: Pienaar, Ongepubliseer, 1947).

sellaag breed. By *Clivia caulescens* (fig. 12) en by *Haemanthus albiflos* besit die selle spiraalvormige wandverdikkings. Wortelhare wat op die velamen aanwesig is, besit ook sodanige verdikkings in hul wande. By *Boophone disticha* (fig. 13) besit die tangensiale wande van die velamenselle penvormige verdikkings wat in die sellumen inskiet. Die velamenselle van *Boophone guttata* besit geen wandverdikkings nie. Die velamenselle het geen protoplasmatiese inhoud of intersellulêre ruimtes nie.

Die velamenselle van die ondersoekte Agapanthus-soorte het geen spiraalvormige of ander wandverdikkings nie en is dus struktureel eenvoudiger as die ondersoekte Amaryllidaceae-soorte (behalwe *Boophone guttata*).

### Skors

Soos by die Agapanthus-soorte differensieer die buitenste sellaag van die skors as 'n eksodermis wat bestaan uit groot selle en kleiner deurlaatselle. Die groot selle is meesal dunwandig en sonder 'n protoplasmatiese inhoud. In teenstelling met die Agapanthus-soorte is die buitenste tangensiale wande van die deurlaatselle sterk verdik en effens verkurk bv. by *Clivia caulescens* (fig. 12). Eenvoudige stippels is waargeneem in die verdikte wande van die deurlaatselle by *Haemanthus albiflos*. Soos by die Agapanthus-soorte besit die deurlaatselle 'n duidelike protoplasmatiese inhoud.

Op die eksodermis volg 'n hele aantal lae dunwandige parenchiemselle met 'n protoplasmatiese inhoud en intersellulêre ruimtes. Slymselle, soos hulle voorkom by die Agapanthus-soorte, is nie waargeneem nie. Rafide-bundels van kalsiumoksalaat kom in sommige van die skorselle voor en die skors word aan die binnekant afgesluit deur een laag endodermiselle wat dunwandig is behalwe vir bande van Caspary in die radiale wande. Die selle besit 'n protoplasmatiese inhoud en geen sekondêre of tersiêre wandverdikkings is waargeneem nie.

### Sentrale silinder

Aan die binnekant van die endodermis kom een laag dunwandige perisikelselle voor met 'n protoplasmatiese inhoud. Daar is 'n groot aantal xileem- en floëmgroepe. Die protoxileemvate is klein, dikwandig, verhout en min in aantal. Elke xileemgroep besit een of meer groot metaxileemvate wat ook dikwandig en verhout is. Die xileemgroepe word begrens deur parenchiemselle van die murg.

Die dunwandige sifvate en enkele begeleidende selle van die floëmgroepe kan duidelik onderskei word tussen die arms van die xileemgroepe. Die res van die sentrale silinder word in beslag geneem deur die murg, wat bestaan uit dunwandige parenchiemselle met 'n protoplasmatiese inhoud en intersellulêre ruimtes.

Die bou van die sentrale silinder stem ooreen met dié van die Agapanthus-

soorte behalwe dat by *Agapanthus orientalis* en *A. inapertus* dikwandige, verhouete parenchymsele in die murg voorkom.

Daar kan hier ook gemeld word dat *Tulbaghia* ook deur Hutchinson (1959) onder die Amaryllidaceae geplaas word en wel onder dieselfde tribus as *Agapanthus*. In die huidige ondersoek is die wortels van *Tulbaghia alliacea* anatomies ondersoek. Die wortelbou verskil van die huidige ondersoekte *Agapanthus*- en Amaryllidaceae-soorte in onder meer die volgende opsigte:

- a. Velamen is afwesig,
- b. Geen slymselle, soos by die *Agapanthus*-soorte, is waargeneem nie,
- c. Meeste van die endodermissele is in die tersiêre toestand en
- d. Min xileemgroepies kom voor en die murggedeelte word in beslag geneem deur een of meer groot metaxileemvate.

Daar kan nie op basis van die wortelanatomie alleen, onderskei word tussen die ondersoekte Amaryllidaceae- en *Agapanthus*-soorte nie.

Wat die wortelanatomie betref, is die idee van Hutchinson (1959) dus geregverdig.

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## **XI INTERNATIONAL BOTANICAL CONGRESS SEATTLE, WASHINGTON, U.S.A.**

The XI International Botanical Congress will meet at the University of Washington, Seattle, Washington, U.S.A., from August 24 to September 2, 1969. The First Circular giving information regarding the Congress has already been mailed to more than 40,000 individuals and organizations. If you wish to receive one, write to:

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'n ANATOMIESE EN ONTOGENETIESE  
STUDIE VAN DIE WORTELS VAN  
SUID-AFRIKAANSE LILIACEAE:

III. DIE ONTOGENIE EN MORFOLOGIE VAN  
DIE VELAMEN EN DIE EKSODERMIS.\*†

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ABSTRACT

The present work deals with the ontogeny and morphology of the velamen and the exodermis in the roots of nine species of the Liliaceae occurring in South Africa.

Velamen is the product of the protoderm. In the Liliaceae it is structurally very simple and is characterised mainly in being many-layered. Only in one species fibrillar wall thickenings and simple pits were observed in the cells of the velamen.

The velamen is delimited from the cortex by an exodermis which may be one- or many-layered. The exodermis is ontogenetically related to the cortex and not to the protoderm, and is composed of large and small cells. The latter are passage cells which usually possess protoplasmic contents and thin cell walls. In some species however, the passage cells have thick outer tangential walls. Simple pits may be present in the walls of exodermal cells.

Hyphae, belonging to some unknown fungus, were observed in the cells of the velamen of one species.

INLEIDING

Die ontwikkeling van 'n spesiale weefsel, die velamen, uit die protoderm van sommige monokotiele lug- en grondwortels is nou reeds algemeen bekend.

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\* Deel van 'n verkorte weergawe van 'n proefskrif goedgekeur vir die graad van Doktor in die Natuurwetenskappe aan die Universiteit van Stellenbosch, September 1965.

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Oor die strukturele kenmerke van die velamen bestaan daar egter nog heelwat meningsverskille.

In die huidige ondersoek is 'n studie gemaak van die velamen en die eksodermis by nege Suid-Afrikaanse soorte van die Liliaceae.

Uit die beskikbare literatuur is die eerste verwysing na velamen by die Liliaceae deur Rywosch (1909) en wel vir *Agapanthus umbellatus* (nou *A. africanus* (L.) Hoffmng.).

Haberlandt (1914) gee 'n algemene oorsig van die velamen by monokotiele. Die velamen is die produk van die protoderm en kan soms een sellag breed wees. Die selwande word versterk deur spiraalvormige verdikkings wat ewewydig of netvormig kan wees. Daar word ook vasgestel dat sg. dekselle aanwesig is in die velamen, direk aan die buitekant van die deurlaatselle in die eksodermis.

In verband met die velamen verwys Goebel (1922) ook na *Agapanthus umbellatus* asook na ander monokotiele. Hy steun die bevindings van Haberlandt (1914) maar beklemtoon die noodsaaklikheid van 'n deeglike ondersoek na die velamen by grondwortels.

Arber (1925) beskryf die velamen by *Asparagus sprengeri* as 'n haardraende laag ("piliferous layer") bestaande uit dooie, leë selle wat soms delikate, netvormige wandverdikkings besit.

Pax en Hoffmann (1930) skryf: „Bei vielen Amaryllidaceen ist wie bei manchen Liliaceen an dem Wurzeln ein mehrschichtiges Velamen aus toten Zellen festgestellt worden”.

Mulay en Deshpande (1959) lewer 'n besondere bydrae tot die ontogenie en morfologie van die velamen by die Liliaceae. Dit vertoon nie spiraalvormige wandverdikkings nie en is struktureel baie eenvoudig. In baie gevalle word die velamen alleen deur die aanwesigheid van stippels gekenmerk of deur 'n korrelagtige laag teenaan die eksodermis. Die velamen ontwikkel uit die protoderm en die breedte wissel van een tot tien sellae.

Deshpande (1960) ondersoek die velamen by *Agapanthus africanus* (as een van die Amaryllidaceae volgens Hutchinson, 1959), en kom tot die volgende gevolgtrekking: "The presence of fibrillar thickenings in addition to pits on the cell walls of the velamen of the Amaryllidaceae, clearly indicate a structural advance over the velamen of the Liliaceae which has only pits (except *Hemerocallis fulva*)". Deshpande maak ook 'n besondere studie van die eksodermis by die Liliaceae en die Amaryllidaceae.

#### MATERIAAL EN METODES

Sien Pienaar (1968 a, p. 38—39 en 1968 b, p. 92—93).



# ONDERSOEK

Velamen en eksodermis kom voor by die volgende 9 soorte uit 'n groep van 35 soorte wat ondersoek is:

Sub-familie	Naam van die soort	Aantal velamenlae	Aantal eksodermislae
ASPHODELOIDEAE	Bulbinella robusta Kunth	2	3—4
ALLIOIDEAE	Agapanthus campanulatus Leighton	3—5	1
"	A. caulescens Sprenger	4—5	1
"	A. comptonii Leighton	4—5	1
"	A. inapertus Beauv.	3—5	1
"	A. orientalis Leighton	2—3	1
"	A. pendulus (L. Bol.) Leighton	3—4	1
"	A. praecox Willd.	3—5	1
ASPARAGOIDEAE	Asparagus compactus Salter	3	4—5

Die wortels van al die bg. soorte is meerjarig.

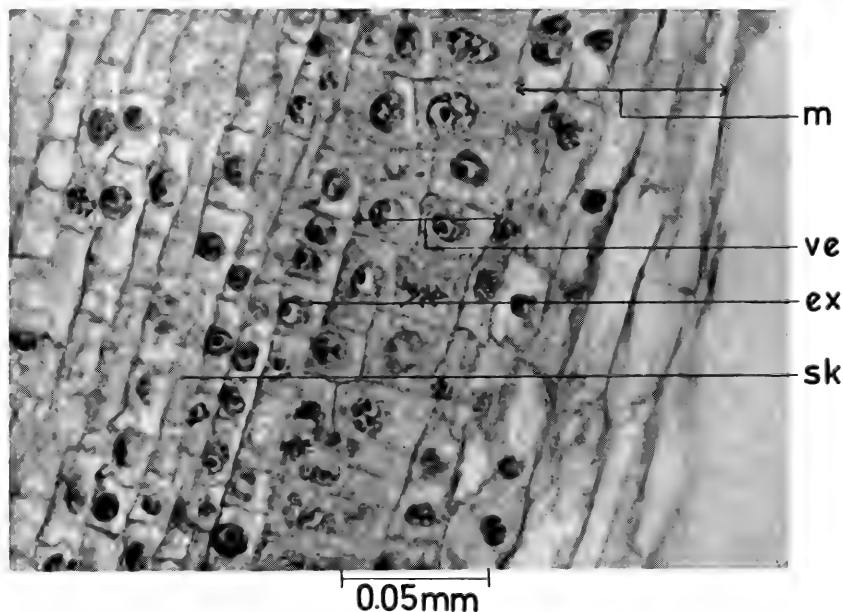


Fig. 1. *Agapanthus praecox*. Radiale lengtesnee van die buitenste sellae van die wortel sowat 0.3 mm vanaf die apikale meristeem: ex, eksodermis; m, wortelmussie; sk, toekomstige skors; ve, protoderm verdeel periklinaal om die velamen te vorm. Let daarop dat die twee sellae van die velamen reeds op hierdie vroeë stadium nie radiaal lê nie.

### Velamen

Die velamen ontwikkel deur periklinale verdelings van die protodermselle. By *Agapanthus praecox* (fig. 1) is die eerste periklinale verdelings van die protoderm sowat 0.3 mm vanaf die apikale meristeem. Deur antiklinale selverdelings neem die velamen toe in omtrek saam met die wyerwordende wortel en word die radiale rangskikking van die selle gewoonlik versteur. Hierdie versteuring kan waargeneem word in dwarsnee van volwasse wortels.

Die jong velamenselle het duidelike kerne en 'n digte protoplasmatische inhoud (fig. 1). Die velamenlae word vir 'n lang afstand agter die apikale meristeem bedek deur die wortelmussie. Waar die wortelmussie nie meer teenwoordig is nie, begin die velamenselle vakuoleer en kan daar wortelhare ontwikkel uit die buitenste laag velamenselle. In die jong toestand is die wortelhare dunwandig, besit 'n protoplasmatische inhoud en funksioneer waarskynlik as absorpsie-strukture. Wortelhare is nog aanwesig op die velamen van die oudste dele van die wortels by *Bulbinella robusta* en die *Agapanthus*-soorte (fig. 2). Hierdie blywende wortelhare is soms sonder 'n protoplasmatische inhoud en die wande

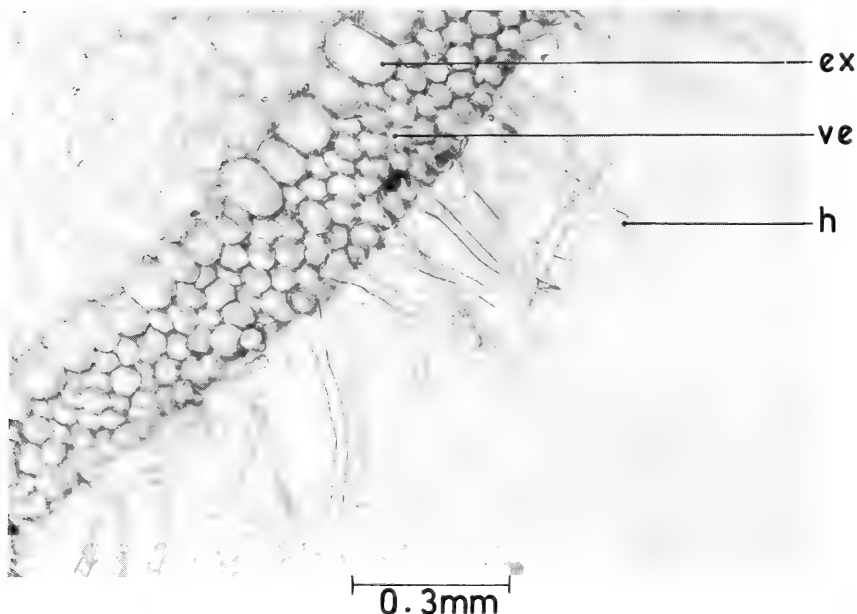


Fig. 2. *Agapanthus comptonii*. Dwarsnee van die buite deel van die wortel: ex, eksodermis; h, wortelhare; ve, velamen.

is effens verhout (vgl. Cormack, 1962). Sulke wortelhare dien waarskynlik net vir vashegting.

Meeste van die volwasse velamenselle is dood en sonder 'n protoplasmatiese inhoud. Geen intersellulêre ruimtes kom tussen die velamenselle voor nie. Die selle is effens dikwandig en verkurk. In 'n dwarsnee is die selle min of meer veelhoekig en effens radiaal gerangskik. In 'n lengtesnee is die selle verleng, ewewydig met die lengte-as van die wortel (vgl. *Asparagus compactus*, fig. 3).

Geen spiraalvormige wandverdikkings of stippels is in die velamenselle van *Bulbinella robusta* en die *Agapanthus*-soorte waargeneem nie. By *Asparagus compactus* (fig. 3) is geringe spiraalvormige wandverdikkings en enkele eenvoudige stippels waargeneem.

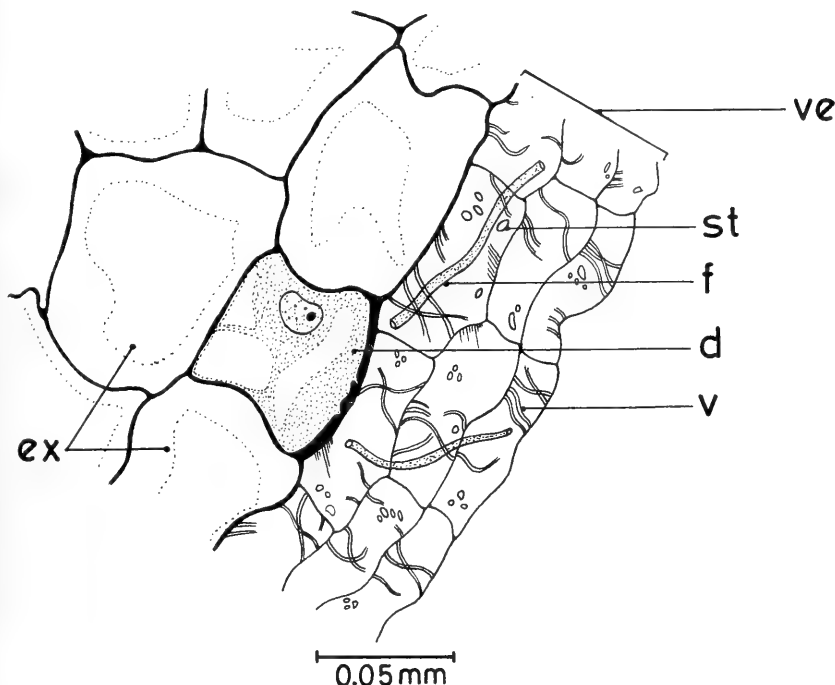


Fig. 3. *Asparagus compactus*. Lengtesnee van 'n gedeelte van die velamen en die eksodermis: ex, eksodermis; d, deurlaatsel; f, hife van 'n fungus; st, stippelopening; v, spiraalvormige wandverdikkings; ve, velamen. Let op die stippels in die verdikte buitenste tangensiale wand van die deurlaatsel.

Hifes van die een of ander fungus is hier en daar waargeneem in die velamenselle en in die dieperliggende sellae by *Asparagus compactus* (fig. 3).

### Eksodermis

Aan die binnekant word die velamen altyd afgebaken deur 'n eksodermis, wat uit een of meer sellae bestaan (vgl. tabel hierbo). In die huidige studie word die term eksodermis verkies bo die term „hipodermis” (van Fleet, 1950) vir die subepidermiese skorslaag(-lae) in die wortel, wat differensieer as 'n beskeringsweefsel met suberien in die selwande (vgl. ook Esau, 1953, p. 481 en Deshpande, 1960, p. 598). Ontogeneties is die eksodermis verwant aan die skors, want dit differensieer uit die grondmeristeem en nie uit die protoderm nie (vgl. Pienaar, 1968 a, p. 50).

Die eksodermis bestaan uit twee soorte selle, nl. groot selle wat hier en daar afgewissel word deur kleiner deurlaatselle. Lg. selle is veral duidelik waarneembaar in 'n lengtesnee (vgl. *Asparagus compactus*, fig. 3). In hierdie sneë vertoon die groot eksodermisselle gewoonlik ewewydig verleng met die wortel-as, terwyl die deurlaatselle hulle vorm behou, kort bly en min of meer afwisselend met die groot selle voorkom. By *Bulbinella robusta* en *Asparagus compactus*, waar die eksodermis meer as een sellaa breed is, kom die kleiner deurlaatselle net in die buitenste sellaa voor. Die groot eksodermisselle is in meeste gevalle dood en sonder 'n protoplasmatiese inhoud, terwyl die deurlaatselle 'n duidelike protoplasmatiese inhoud besit. Die buitenste tangensiale en die radiale wande van die eksodermisselle is meesal effens verdik en verkurk. By *Asparagus compactus* (fig. 3) is die buitenste tangensiale wande van die deurlaatselle baie meer verdik as soortgelyke wande van die ander eksodermisselle (sien later).

Die buitenste tangensiale wande van die eksodermisselle by *Agapanthus praecox* (fig. 4) vertoon dun penvormige verdikkings wat reghoekig in die sellumen inskiet.

Eenvoudige stippels kan in die wande van die eksodermisselle voorkom, veral in die buitenste tangensiale wande van die deurlaatselle, bv. by *Asparagus compactus* (fig. 3).

Daar moet op gewys word dat 'n eksodermis ook voorkom by 'n hele aantal soorte wat geen velamen het nie, bv. by *Kniphofia ensifolia* (een laag eksodermisselle) en by *Bulbine caulescens* ('n aantal lae eksodermisselle). (Vgl. Pienaar, 1968 b, p. 94—96).

### BESPREKING

#### A. Velamen

##### (i) *Spiraalvormige wandverdikkings*

Behalwe by *Asparagus compactus*, is spiraalvormige wandverdikkings nie

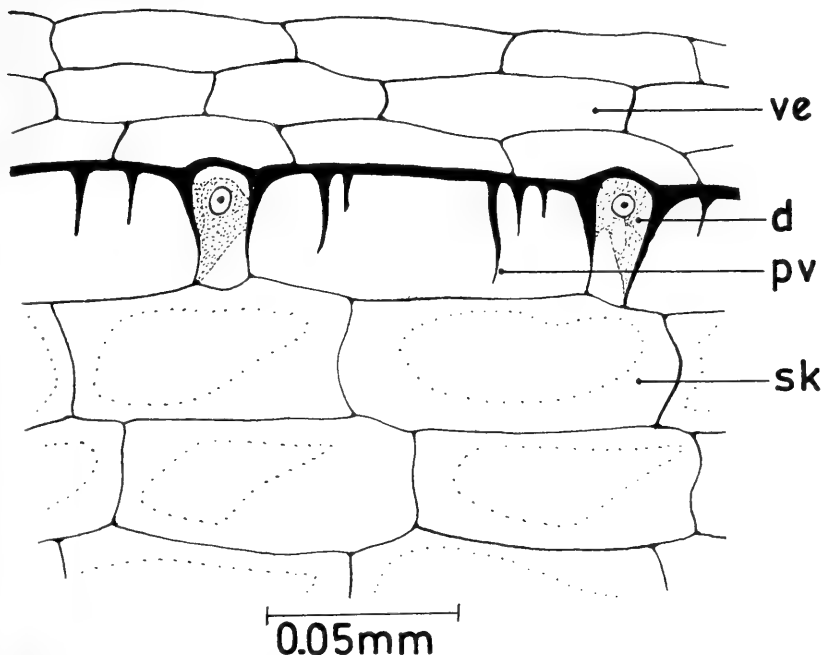


Fig. 4. *Agapanthus praecox*. Radiale lengtesnee van die buitelaie van die wortel: d, deurlaatsel, met 'n protoplasmatische inhoud, in die eksodermis; pv, penvormige verdikking van die eksodermiswand wat inskiet in die sellumen; sk, skors; ve, velamen.

waargeneem in die velamen van die huidige ondersoekte soorte nie. Deshpande (1960) ondersoek *Agapanthus africanus* en stel vas dat daar in die velamenselle (5—7 lae breed) wel spiraalvormige wandverdikkings aanwesig is. In die huidige ondersoek is sewe *Agapanthus*-soorte ondersoek en by nie een van die soorte is daar sodanige wandverdikkings in die velamen waargeneem nie. Dit is ook die geval by die velamen van *Bulbinella robusta*. By hierdie soorte kon die velamen dus net uitgeken word as 'n weefsel wat meer as een sellaaag breed is en wat ontstaan het uit die protoderm, m.a.w. dit is 'n meerlagige epidermis.

Mulay en Deshpande (1959) skryf soos volg oor 'n eenlagige velamen by die Liliaceae: "Many plants in the present investigation possess one-layered velamen. All these species possess thickenings characteristic of velamen". Die soorte wat deur hulle ondersoek is en waar 'n eenlagige velamen geïdentifiseer is, sluit o.m. in: *Dracaena angustifolia*, *Chlorophytum elatum*, *Anthericum*

*variegatus* en *Sansevieria hahnii*. Ander soorte van dieselfde genera is in 'n vorige ondersoek (Pienaar, 1968 b) bestudeer, maar geen velamen is waargeneem nie. Daar is ook nie spiraalvormige wandverdikkings in die epidermisselle nie. Ongelukkig dui bg. navorsers nie hierdie wandverdikkings in hulle sketse aan nie en word daar aan die anderkant in die opsomming gesê: "In Liliaceae velamen is structurally very simple and is characterised by pits only". Goebel (1922) stel dit ook dat die aanwesigheid van spiraalvormige wandverdikkings nie 'n essensiële faktor is om velamen uit te ken nie, in al die gevalle waar dit aan die binnekant afgebaken word deur 'n duidelike eksodermis.

(ii) *Dekselle en Komplementêre selle*

Mulay en Deshpande (1959) skryf ook: "Another feature of interest is the presence of two small covercells just above the passage cell which are formed

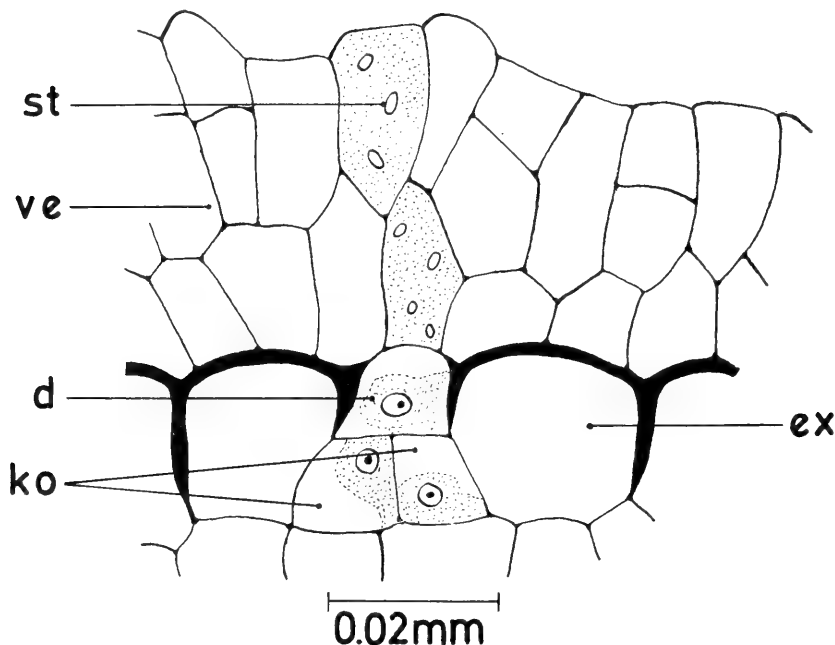


Fig. 5. *Sansevieria thyrsiflora*. Dwarssnee van die buitelaai van die wortel: d, deurlaatsel met 'n dun buitenste tangensiale wand en 'n protoplasmatiese inhoud; ex, eksodermis, waarvan die buitenste tangensiale wande en die radiale wande verdik is; ko, komplementêre selle; st, stippels in die velamen (ve). (Nagetekens uit: Mulay en Deshpande, 1959).

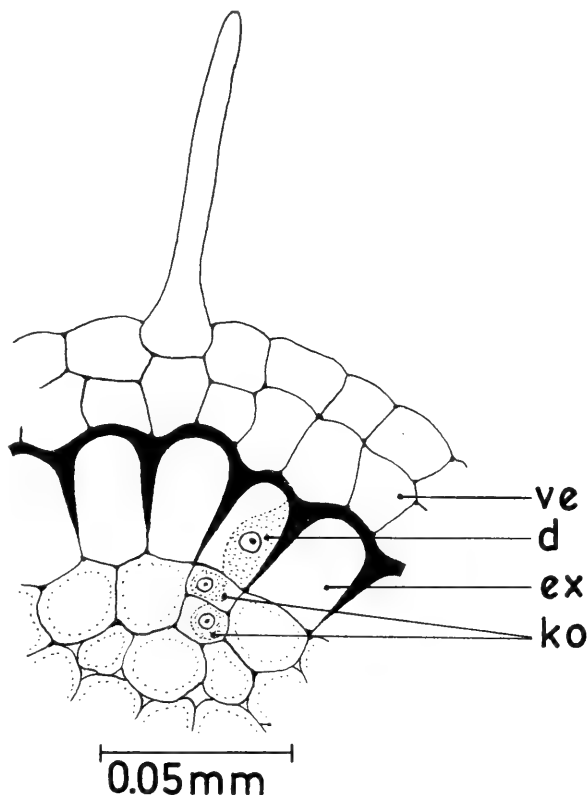


Fig. 6. *Agapanthus orientalis*. Dwarssnee van 'n gedeelte van die buitedeel van die wortel: d, deurlaatsel in die eksodermis (ex); ko, moontlike komplementêre selle; ve, velamen met o.m. 'n wortelhaar.

from the velamen cells. Just beneath the passage cells also there occur one or two small cells called complementary cells which are formed from the passage cell. These cells possess nuclei and cytoplasm". (Sien fig. 5). Dekselle is nie waargeneem by die velamen in die huidige ondersoek nie. Komplementêre selle kom moontlik voor by *Agapanthus orientalis* (fig. 6). Hulle word nie heeltemal as komplementêre selle beskou nie omdat hulle nie in dieselfde laag as die eksodermis lê nie (vgl. fig. 6 met fig. 5). Dit is ook nie seker of hulle uit die deurlaatsel gevorm is nie, hoewel hulle in dieselfde radiale selry lê.

(iii) *Korrelrige stof*

'n Verdere kenmerk waarna Mulay en Deshpande (1959) en Deshpande (1960) verwys, is die aanwesigheid van 'n korrelrige stof ("granular matter") in die velamenselle wat grens teenaan die eksodermiselle (fig. 7). Volgens Mulay

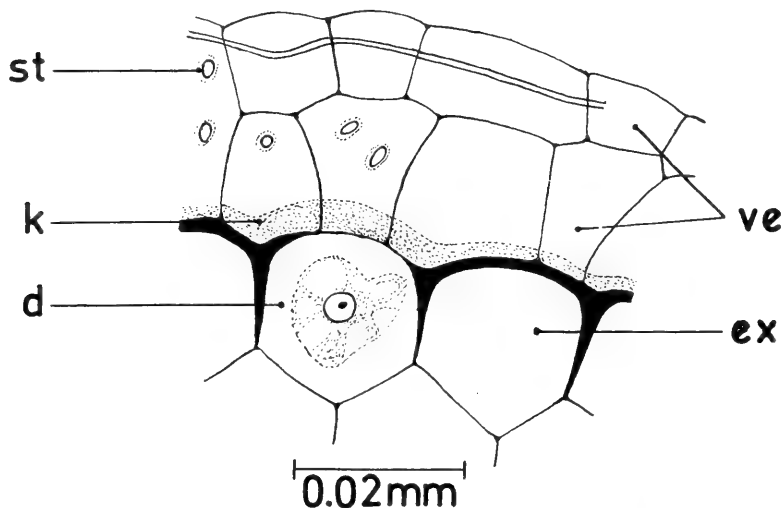


Fig. 7. *Polygonatum oppositifolium*. Dwarssnee van die buitelaai van die wortel: d, deurlaatsel met 'n dun buitenste tangensiale wand en 'n protoplasmatische inhoud; ex, eksodermis; k, korrelrige stof; st, stippels in die velamenselle (ve). In lg. kom ook 'n hife van 'n fungus voor. (Nageteken uit Mulay en Deshpande, 1959).

en Deshpande (1959) stem hierdie korrelrige stof ooreen met dié gevind deur Goebel (1922) by *Aspidistra elatior* en *Anthurium ellipticum*, maar blykbaar nie met die "fibrous bodies" van Haberlandt (1914, p. 234, fig. 90) nie. In die huidige ondersoek is sodanige korrelrige stof nie by een van die soorte met 'n velamen waargeneem nie.

In hulle sketse van die plantsoorte met 'n velamen wat net een sellaa breed is, toon Mulay en Deshpande (1959) en Deshpande (1960) een of meer van die volgende kenmerke aan: korrelrige stof, stippels, komplementêre selle (nêrens dekselle nie) en altyd 'n eksodermis aan die binnekant van die velamen. Dit wil dus voorkom of een of meer van hierdie kenmerke voldoende is om 'n eenlagige velamen uit te ken, volgens hierdie outeurs.

Die velamen by die huidig ondersoekte soorte van die Liliaceae kan hoofsaaklik uitgeken word as 'n oppervlakkige weefsel wat 'n aantal sellae breed is, m.a.w. die "multiseriate epidermis" van Eames en MacDaniels (1947)



en van Esau (1953), en dit is sonder korrelrige stof, dekselle of wandverdikkings maar altyd met 'n eksodermis aan die binnekant van die velamen. Geringe wandverdikkings en eenvoudige stippels is egter waargeneem by *Asparagus compactus*, en moontlike komplementêre selle by *Agapanthus orientalis*.

#### B. Dikwandige deurlaatselle in die eksodermis

Nieteenstaande die algemene opvatting dat die deurlaatselle in die eksodermis dunwandig is, is daar in die huidige ondersoek en in 'n vorige ondersoek (Pienaar, 1968, b) vasgestel dat dit nie altyd die geval by volwasse dele van die wortels is nie, bv. by *Asparagus compactus*, *Anthericum galpinii*, *Kniphofia ensifolia*, *Haworthia tessellata* en *Veltheimia deasii*. By hierdie soorte is die buitenste tangensiale wande van die deurlaatselle meer verdik as die buitenste tangensiale wande van die ander eksodermisselle. Soortgelyke deurlaatselle is ook waargeneem deur Mulay en Deshpande (1959) by *Hemerocallis fulva*. Die verdikte wande mag ook effens of meer verkurk wees. Die deurlaatselle besit 'n protoplasmatiese inhoud.

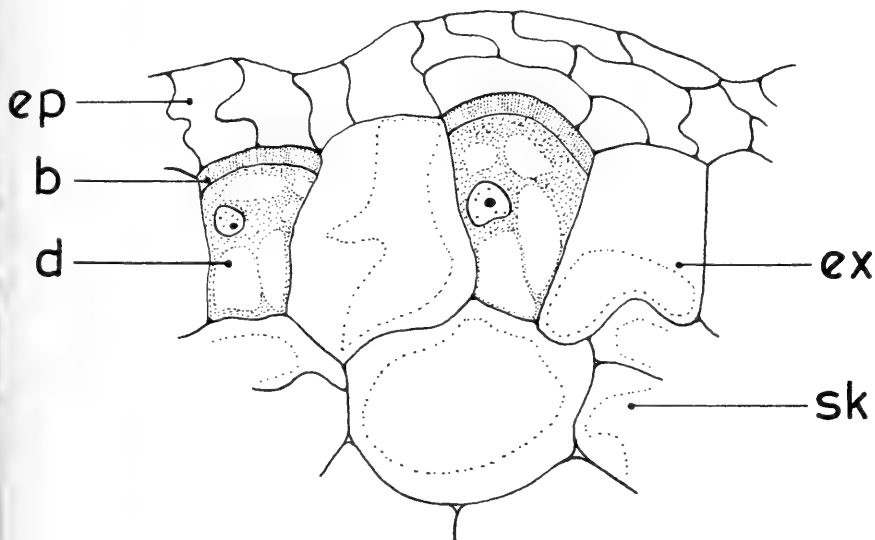


Fig. 8. *Hoya carnosa*. Dwaarsnee van die buitenste lae van die lugwortel: b, verdikte, fyn geperforeerde buitewand van die deurlaatsel (d) in die eksodermis (ex); ep, epidermis; sk, skorsparenchiem. (Nageteken uit: Von Guttenberg, 1956, p. 100).

Von Guttenberg (1965, p. 99, fig. 96, 99) beskryf ook deurlaatselle van die eksodermis met 'n protoplasmatiese inhoud en sterk verdikte buitenste tangensiale wande by *Hoya carnosa* (vgl. fig. 8) en by *Clivia nobilis*. (Vgl. ook *Clivia caulescens*, Pienaar, 1968 b). Von Guttenberg sê dat hierdie verdikte buitewande deurlaatbaar is en dat 'n suberienlamella afwesig is. Die verdikte buitewand is egter fyn geperforeer. Dat die wande van die eksodermiselle wel verkurk mag wees, word beskryf deur Haberlandt (1914, p. 233).

In die jong (onvolwasse) wortels van die huidig ondersoekte soorte bestaan die eksodermis ook uit groot selle en kleiner deurlaatselle, maar die selwande is almal dun en nie verkurk nie. Die verdikking en verkurking van die selwande begin eers in die ouer dele van die wortels. Of hierdie dele van die wortels nog water uit die grond opneem, is nie duidelik nie. (Vgl. ook Pienaar, 1968 b, p. 106).

Geen bande van Caspary, soos waargeneem deur Deshpande (1960) in die eksodermiselle van sommige soorte wat hy ondersoek het, is in die huidig ondersoekte soorte waargeneem nie.

Die aanwesigheid van eenvoudige stippels in die wande van die eksodermiselle, bv. by *Asparagus compactus*, stem ooreen met die bevindings van Deshpande (1960) vir die eksodermis van soorte van die Liliaceae en die Amaryllidaceae wat hy ondersoek het.

#### OPSOMMING

1. Waar 'n velamen by die ondersoekte soorte voorkom, is dit meer as een sellag breed en 'n produk van die protoderm.
2. Wortelhare kom voor op die velamen selfs in baie ou dele van die wortels (naby die basis van die wortel).
3. Behalwe vir effense wandverdikkings by *Asparagus compactus*, is spiraalvormige wandverdikkings nie waargeneem in die velamenselle nie. Stippels mag voorkom in die velamenselle, bv. by *Asparagus compactus*.
4. 'n Eksodermis (een of meer sellae breed) grens teenaan die binnekant van die velamen en dit is deel van die skors. Geen bande van Caspary is in die eksodermiselle waargeneem nie.
5. By sommige soorte, bv. *Asparagus compactus*, is die buitenste tangensiale wande van die deurlaatselle in die eksodermis meer verdik en verkurk as die wande van die ander eksodermiselle.
6. Geen korrelrige stof of dekselle is waargeneem by die huidig ondersoekte soorte nie. Komplementêre selle kom moontlik voor by een van die ondersoekte soorte, nl. by *Agapanthus orientalis*.
7. Struktureel is die velamen by die huidig ondersoekte soorte van die Liliaceae eenvoudiger as die velamen by sommige soorte van die Orchidaceae en

die Amaryllidaceae (vgl. *Clivia caulescens*, Pienaar, 1968 b, fig. 12), omdat duidelike spiraalvormige wandverdikkings afwesig is.

8. 'n Onbekende fungus-soort is waargeneem in die velamenselle van *Asparagus compactus*.

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# NOTES ON *CERAMIUM PLANUM* KUETZ., A RED SEAWEED FROM SOUTH AFRICA†

R. H. SIMONS

(Government Marine Algologist, University of Cape Town)\*

*Ceramium planum* Kuetz., has been thought to include as synonyms, *Ceramium cancellatum* Ag. and *Pteroceras flexuosum* Kuetz. (Simons, 1966 and Papenfuss, 1952). Certain facts have emerged which confuse this interpretation. The facts are these: two forms, sufficiently distinct to be regarded as separate species, have recently been distinguished in the present concept of *C. planum*; these two forms can be assigned respectively to *C. cancellatum* sensu J. Agardh (1894) and *C. flexuosum* sensu J. Agardh (1894); the morphology of these two forms is peculiar in that the older portions are pervaded by cortical hyphae; a third specific entity, obviously closely related, has also been distinguished.

For the purposes of the present discussion these three species together will be referred to as *Ceramium planum* sensu lato.

The emergence of these facts raises several questions. If *C. planum* Kuetz. does indeed contain *C. cancellatum* Ag. and *Pteroceras flexuosum* Kuetz. as has been thought, then these three names must apply to only one of the three species in *Ceramium planum* sensu lato. The question is, which one? One of the three species is definitely excluded which leaves a choice of two. These two are too alike and too easily confused if considered superficially to allow a definite decision based on the information available in the literature. If on the other hand the present concept of *C. planum* Kuetz. is wrong and this species contains neither *C. cancellatum* Ag. nor *Pteroceras flexuosum* Kuetz., or alternatively it contains only one of them, several questions remain to be

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\* Currently in the Department of Agricultural Technical Services, Botanical Research Institute.

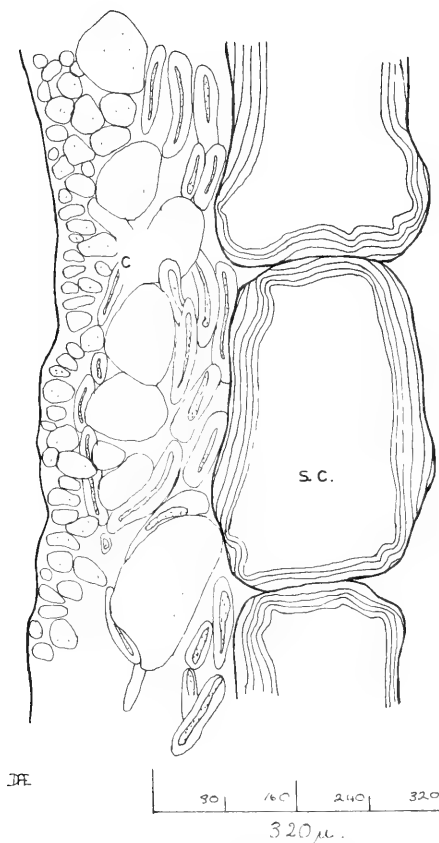


FIG. 1. *C. planum* sensu lato. Portion of longitudinal section of Simons 695A, showing central cells and part of the radially symmetrical cortical envelope. s.c.: central cells; c.: cortex.

Del. D. A. Ellis.

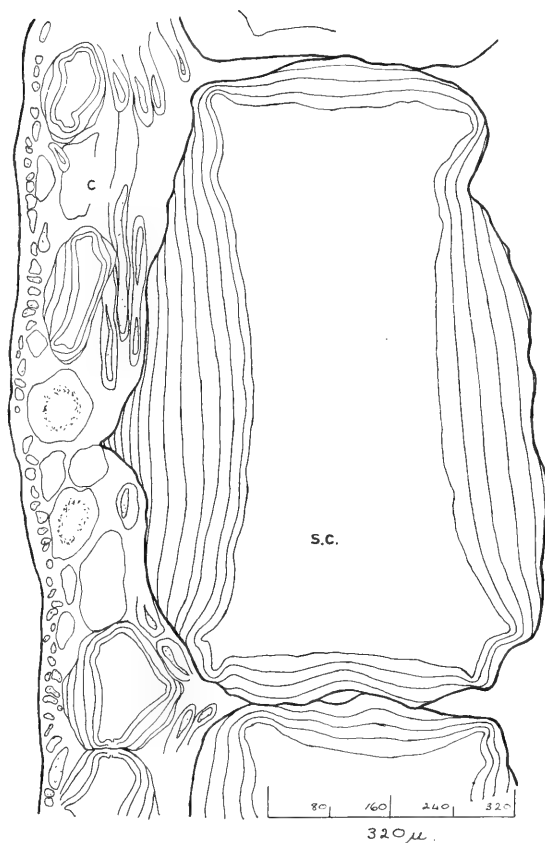


FIG. 2. *C. planum* sensu lato. Portion of longitudinal section of Simons 695B, showing central cells and part of the radially symmetrical cortical envelope. s.c.: central cells; c.: cortex.

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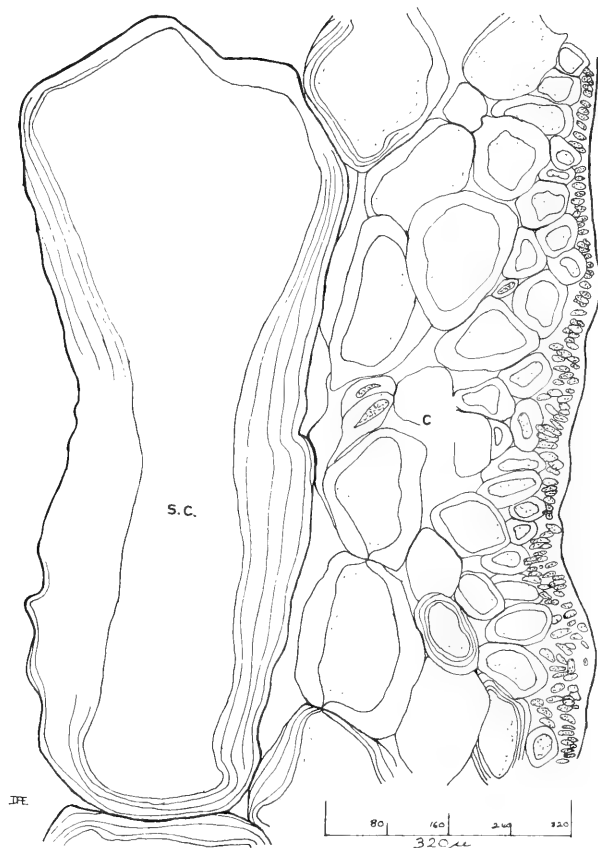


FIG. 3. *C. planum* sensu lato. Portion of longitudinal section of Simons 1900, showing central cells and part of the radially symmetrical cortical envelope. s.c.: central cells; c.: cortex.

Del. D. A. Ellis.



answered. The literature again provides only vague indications of these answers. Kuetzing (1849 and 1863, tabs. 11 and 22) distinguished *Ceramium planum*, *C. cancellatum* and *Pteroceras flexuosum* as separate species and in fact erected the genus *Pteroceras* (Kuetzing, 1849) to contain *Ceramium cancellatum* Ag. and his newly described *Pteroceras flexuosum*. Few authorities, however, have accepted most of Kuetzing's generic near-relatives of *Ceramium* and the name *Pteroceras* was one of those to be rejected almost from the date of its inception. Thus J. Agardh in 1851 returned *Pteroceras cancellatum* (Ag.) Kuetz. to the genus *Ceramium* and followed Grunow by placing *P. flexuosum* Kuetz. in *Ceramium* too. Later authorities have continued this practice. In his discussion of these species J. Agardh (1851) claimed that *C. flexuosum* (Kuetz.) Grun. was probably identical to *C. cancellatum* Ag., and certainly on the basis of Kuetzing's descriptions of the two species concerned, this view would appear to have been justified. In this same publication (J. Agardh, 1851) *Ceramium planum* Kuetz. was included in the section '*species inquirendae*' with the suggestion that it belonged in a group of three species which included *C. cancellatum* Ag. Thus the identity of *Ceramium planum* Kuetz., as early as two years after its first publication, was already vague. In his later publications dealing with the species of *Ceramium*, J. Agardh (1876 and 1894) made no mention of *Ceramium planum* Kuetz., but in 1894 (l.c.) he distinguished *C. cancellatum* Ag. from *C. flexuosum* (Kuetz.) Grun. and gave them each specific status. That there are two species in *C. planum* sensu lato which can be assigned to *C. cancellatum* sensu J. Agardh (1894) and to *C. flexuosum* sensu J. Agardh (1894) cannot be disputed but whether in point of fact J. Agardh's use of these names is correct is a different matter; the conclusion of Papenfuss (l.c.) seems to rule against the correctness of J. Agardh. So the confusion remains. De Toni's (1903) tentative suggestion that *C. planum* Kuetz. is a synonym of *C. cancellatum* Ag. merely demonstrates more clearly that the species was not understood. Papenfuss's (l.c.) and Simons's (l.c.), therefore, remain the only two accounts equating *Ceramium planum* Kuetz., *C. cancellatum* Ag. and *Pteroceras flexuosum* Kuetz., but in the case of Simons this decision was made without the realisation that more than one specific entity was involved in the concept of *C. planum*. So far as can be deduced Papenfuss was also unaware of this taxonomic distinction and it is therefore possible that he was the more easily persuaded to overlook slight morphological differences present in the type specimens of *C. planum* Kuetz., *C. cancellatum* Ag. and *Pteroceras flexuosum* Kuetz. In the light of the presently recorded facts about *Ceramium planum* sensu lato, and because of the vagueness attached to the literary accounts of the species possibly involved, it is imperative that the type specimens of these Kuetzing and Agardh species are again examined.

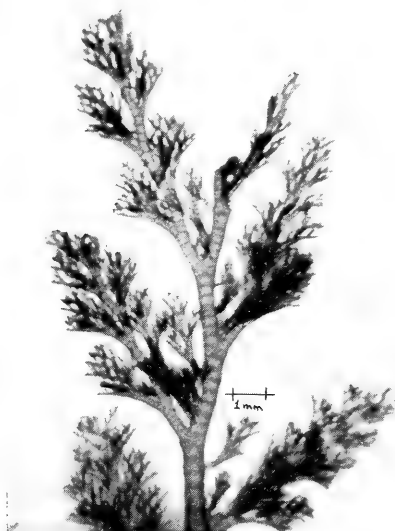


PLATE I.

- A. Terminal portion of an axis of Simons 695A, showing the pattern of branching.  
 B. Terminal portion of an axis of Simons 695B, showing the pattern of branching.  
 C. Terminal portion of an axis of Simons 1900, showing the pattern of branching.

*Photos: R. Simons.*

There is a further problem so far not dealt with, which concerns the peculiar morphology of the species of *C. planum* sensu lato. All three have this in common, that the more mature portions of the axes are pervaded by cortical hyphae besides the more usual rounded or angled cells typical of the species of *Ceramium*. J. Agardh recognised such a construction in a Japanese species formerly assigned to *Ceramium rubrum* var. *virgatum* Ag. J. Agardh (1851) gave this Agardh variety species status and removed it from the genus *Ceramium* placing it as the only species of his genus *Campylaephora*; it then became *Campylaephora hypnaeoides* J. Ag. More recently Hommersand (1963) implied acceptance of the separate generic status of *Campylaephora* J. Ag. based on the presence of ramifying hyphae pervading the cortical tissue of *Campylaephora hypnaeoides* J. Ag., which in other respects complies with his accepted definition of *Ceramium* Roth. Examination of the literature has shown there is only one difference between the species of *C. planum* sensu lato and *Campylaephora hypnaeoides* J. Ag., which might be considered generically significant and this concerns the position of the tetrasporangia; in *C. planum* sensu lato mature sporangia are exerted from the cortex, whilst in *C. hypnaeoides* mature sporangia are immersed in the cortex. Modern interpretations of species of *Ceramium* do not consider the degree of immersion of tetrasporangia sufficiently important to decide their generic affinities and it seems logical, therefore, that the limits of *Campylaephora* should include species with either exerted or immersed tetrasporangia. If then the genus *Campylaephora* is to be accepted, *Ceramium planum* sensu lato must be accepted as belonging to that genus. Pending the results of a further examination of the type specimens of *Ceramium planum* Kuetz., *Ceramium cancellatum* Ag. and *Pteroceras flexuosum* Kuetz., it should be possible to say whether any or all of these species belong to the same genus as *Campylaephora hypnaeoides*, and, therefore, whether the Kuetzing name of *Pteroceras* has priority over *Campylaephora*.

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## TWO NEW STAPELIADS FROM CAPE PROVINCE†

L. C. LEACH

It is rather remarkable that so relatively soon after the discovery of *Stapelianthus choananthus* (Lavranos & Hall) R. A. Dyer, should come, not only the second example of the genus to be found in South Africa but that it should also be a cremnophilous pendulous species and again be found in the same area as plants of *Huernia pillansii* N. E. Brown, albeit a new subspecies of that taxon.

It should perhaps be mentioned that it was only after considerable discussion that it was finally decided to retain the two species in *Stapelianthus*. It was considered that the objections to the erection of a new genus to accommodate them remained the same as when the original transfer from *Stapelia* was effected by Dr. Dyer, and that their generic position should, therefore, remain unchanged, at least while the present somewhat confused situation within the tribe exists.

The comparatively frequent discoveries of new species of Stapeliad in a country so well collected causes one to wonder why they have remained undiscovered for so long. This may sometimes be explained by the phenomenon, often observed by the author to occur among some members of the tribe, of a rapid population "build up" followed by a consequent dramatic reduction in population density, resulting in the virtual disappearance of a species from an area where it had previously been plentiful.

However, no such process appears to have been operative in the present instance as the colony of *Stapelianthus* comprised a considerable number of plants of varying ages (some apparently quite old), while the *Huernia* has been found, also at different stages of development, at three different localities within two or three miles of the original gathering.

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† Accepted for publication 1st March, 1968.

The plants now described were collected while botanising in the Baviaanskloofberg and it is with pleasure that the *Stapelianthus* is now named for my friend and companion on many botanical expeditions, Col. R. D. Bayliss who, with his son William and the writer made up the party on this most interesting and rewarding excursion.

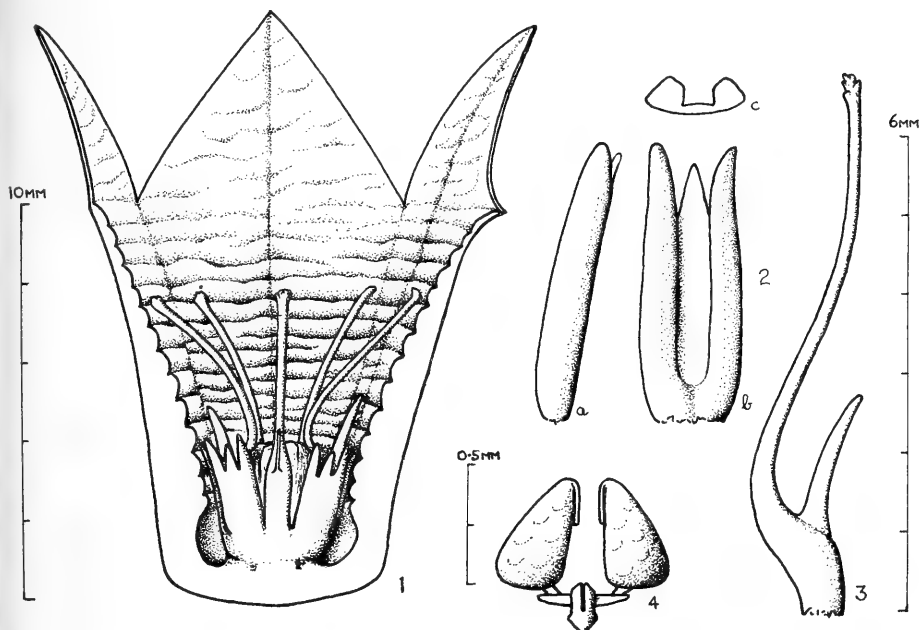
***Stapelianthus baylissii* Leach, sp. nov.**

*Stapeliantho choanantho* (Lavranos et Hall) R. A. Dyer arcte affinis sed caulibus prominentioribus dentatis, apice floriferis; pedunculorum cicatricibus per totam longitudinem caulium dispersis; corollae tubo brevissimo, intra sigillatim transverse ruguloso; coronae interioris cornibus interioribus robustioribus, complanatis apice obtuso vel saepe leviter incrassato; polliniorum forma dissimili et folliculis brevissimis differt.

*Planta* succulenta, cremnophila, caulibus pendentibus. *Caules* quadrangulares, glabri, atro-virides vel in apricis brunnescens, 7—12 mm crassi usque ad 90 cm longi (plerumque 15—25 cm), inter angulos plani, juniores interdum aliquantum sulcati, angulis obtusis sinuato-dentatis, dentibus ad 5 mm altis, demum obsolescentibus, secus angulos 9—13 mm distantibus; caulibus lateralibus similaribus, dentium ex axillis emissis, profunde articulatis. *Flores* aliquot per pedunculum deinceps aperientes. *Pedunculi* crassi, cuspidati, 2—3 mm longi, caulium versus apicem inter angulos emissi; pedunculorum veterum cicatricibus per totam longitudinem caulium dispersis. *Pedicelli* glabri, teretes, 5—13 mm longi, c. 1.5 mm diam. *Sepala* ovato-attenuata, carnosa, convexa, 2.5—3 mm longa; dente minuto carnoso in sinubus inserto. *Corolla* campanulata, in sectione pentagona, glabra, rubropurpurea, 12—15 mm longa, inter apices loborum 12—13 mm diam.; *tubo* 8—10 mm longo, ad orem 9—10 mm diam., intus transverse ruguloso; *lobis* deltatis, erecto-patentis, c. 5 mm longis, basi usque ad 7.5 mm latis; lobis intermediis patentis c. 0.75 mm longis. *Corona* tubi basi exoriens, uniformiter fuscopurpurea, basi c. 3 mm diam., usque ad 7.5 mm alta; coronae exterioris lobis suberecto-patentis, c. 3.5 mm longis, c. 1.2 mm latis, intus prominenter bicarinatis, ad apicem 3-dentatis, dentibus lateralibus 1—1.4 mm longis, dente medio aliquantum brevior; coronae interioris lobis bicornutis, initio supra antheras incumbentibus, c. 0.5 mm latis, deinde cornu interiore parum patulo vel erecto, c. 5.5 mm longo, complanato, c. 0.3 mm lato; apice obtuso vel projecturis angulatis parvulis irregulariter sparsim munito; cornu exteriori erecto vel parum patulo, valde lateraliter compresso, longitudine variantissimus, usque ad 3 mm longo. *Pollinia* plus minusve obtuse triangularia, c. 0.5 mm longa. *Folliculi* fusiformes, plerumque c. 4 cm longi (usque ad 6 cm).

Type: *L. C. Leach & R. D. Bayliss 13617* (K; NBG; PRE, holotypus; SRGH).

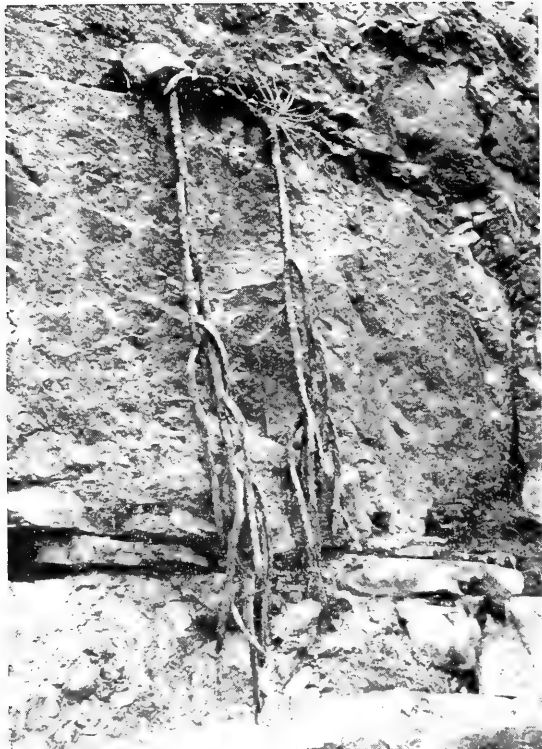
South Africa. Cape, 3324 (Steytlerville), near the eastern end of Baviaans' Kloof (-DA), fl. 30. xii. 1966, and later in cult. at Nelspruit, *Leach & Bayliss* 13617 (K; NBG; PRE; SRGH).



- (1) Section through corolla showing corona.  
 (2) Outer corona lobe: (a) side view (b) inside view (c) section.  
 (3) Inner corona lobe.  
 (4) Pollinia.

FIG. 1. *Stapelianthus baylissii* Leach.

*S. baylissii* is very closely related to *S. choananthus* but the much shorter flowers are produced at the apex of the more prominently toothed pendulous stems which bear the scars of old peduncles for the whole of their length. The inside of the corolla is markedly transversely rugulose and the more robust, somewhat transversely flattened inner corona horns are obtuse or slightly thickened with a few small angular projections at the apex; finally the pollinia are a different shape and the follicles much shorter than are those of its nearest relative.



Cliff habitat at the type locality, Baviaans' Kloof



Apical inflorescence showing rugulose corolla.

PLATE 1. *Stapelianthus baylissii* Leach



In habit the new species bears a remarkable resemblance to the Huis River plants and occupies a very similar habitat, mostly in inaccessible, although generally more open situations, on almost vertical rock cliffs. It seems that the prostrate-pendulous habit is normal, as seedlings, having at first developed a single erect stem have now produced lateral branches from near its base; these are extended horizontally and are continuing to grow in a prostrate position while the initial stem appears to have ceased to grow. It appears that these prostrate branches would, in their normal habitat on ledges on cliff faces, very quickly be forced to assume the pendulous habit of all the plants seen in the wild.

*Plant* succulent, growing on ledges on sheer rock cliffs with the stems pendulous. *Stems* quadrangular (One 6-angled seen), glabrous, dark green in shaded situations, becoming brownish when exposed to the sun, branched from near the base or sparingly and intermittently along the length of the pendulous portions, deeply articulated at the point of attachment in the axils of the marginal teeth, up to 90 cm long (generally 15–25 cm), 7–12 mm thick, with the sides more or less flat between the angles or sometimes, when young, somewhat sulcate, with the scars and remains of old peduncles scattered throughout the length of the stems; the obtuse angles are sinuate toothed, prominently so when young, with the teeth up to 5 mm high, becoming less prominent and finally obscure with age, 9–13 mm apart along the angles. *Inflorescence* borne at or near the apex of the stems on a stout cuspidate peduncle 2.5–3 mm long, situated more or less midway between the angles. *Flowers* several, opening successively. *Pedicels* terete, c. 1.5 mm diam., 5–13 mm long, glabrous, green with numerous, slightly raised, minute whitish flecks. *Sepals* ovate-attenuate, thick and fleshy, convex beneath, 2.5–3 mm long, pale green with minute, whitish, slightly raised flecks, with a minute fleshy tooth in the sinuses. *Corolla* pentagonally campanulate, 12–15 mm long, 12–13 mm diam. across the lobe apices, outside somewhat yellowish at the very base, becoming deep purplish pink towards the apex of the lobes, glabrous or sometimes sparsely obscurely scabrid with slightly raised whitish flecks; inside red-purple, quite glabrous with a slight satin-like sheen. *Tube* 8–10 mm long, c. 7 mm diam. at the base outside, 9–10 mm diam. at the mouth, markedly transversely rugulose within, becoming less deeply so upwards and finally obsolescent on the lobes; there is a marked median groove from the base of the tube to the apex of the lobes so that the tube, towards the base, assumes a more or less decagonal cross-section, outside there is a corresponding nerve which becomes more prominent above. *Lobes* deltate, suberectly spreading or spreading, c. 5 mm long, up to 7.5 mm wide at the base. *Corona* arising from the base of the tube, uniformly dark purple, glabrous, about 3 mm diam. at the base, up to 7.5 mm high; *outer*

*corona* lobes suberectly spreading, c. 3·5 mm long, c. 1·2 mm wide, prominently bicarinate on the inner face, 3-toothed at the apex with the central tooth somewhat shorter than the lateral which are 1—1·4 mm long; *inner corona* lobes 2-horned, c. 6·5 mm long, at first incumbent on the anthers with the inner horn erect or slightly spreading, c. 5·5 mm long, transversely compressed, c. 0·5 mm wide towards the base with the erect portion c. 0·3 mm wide, with the apices obtuse or slightly thickened with a few irregular angular projections; the outer horn laterally much compressed, erect or erectly spreading, very variable in length, up to 3 mm. *Pollinia* more or less obtusely triangular, c. 0·5 mm long. *Follicles* fusiform, widely diverging, generally c. 4 cm long (up to 6 cm).

***Huernia pillansii*** N. E. Brown in Gard. Chron. **35**: 50 (1904) & Fl. Cap. **4**, 1: 909 (1909).—Berger, Stap. und Klein. 168 (1910).—Marloth, Fl. S. Afr. **3**, 1: 95, Pl. 22m (1932).—White & Sloane, Stap. **3**: 957 (1937).—Phillips, Fl. Pl. S. Afr. **22**: t.843 (1942).—Jacobsen, Handb. Succ. Pl. **2**: 627 (1960). Type: S. Africa, Cape Prov., Matjesfontein, *N. S. Pillans* 23 (BOL; GRA).

**Subsp. *pillansii***

South Africa. Cape, 3320 (Montagu): 3 miles E of Matjesfontein (-BA), *Pillans* 23 (BOL; GRA); 23 miles E of Montagu, *Hall* in NBG 229/54 (NBG). 3321 (Ladismith), Ladismith, *Hall* 878 (NBG). 3322 (Oudtshoorn), Prince Albert (-AA), *H. Bolus* 11607 (BOL); Oudtshoorn (-CA), *E. Pillans s.n.* (BOL); Prince Albert, *Ryder s.n.* (GRA); Oudtshoorn Distr., *W. Taylor* 38 (BOL); Oudtshoorn, *Tribelhorn* in NBG 860/61 (NBG). 3324 (Steytlerville), between Steytlerville and Jansenville, *Compton et al.* in NBG 1060/47 (NBG).

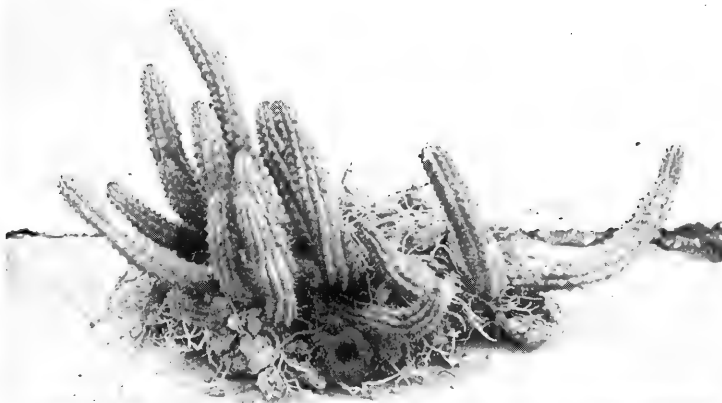
*H. pillansii* subsp. *pillansii* is so well known and illustrated that it is considered unnecessary to include either description or figure in this paper. In view of the setting up of subspecies however, the distribution records are thought to be of some importance.

Subsp. ***echidnopsioides*** Leach, subsp. nov., a subspecie typica caulibus tessellatis angulis paucioribus haud setosis, saepe habitu subterraneo rhizomato bene distincta.

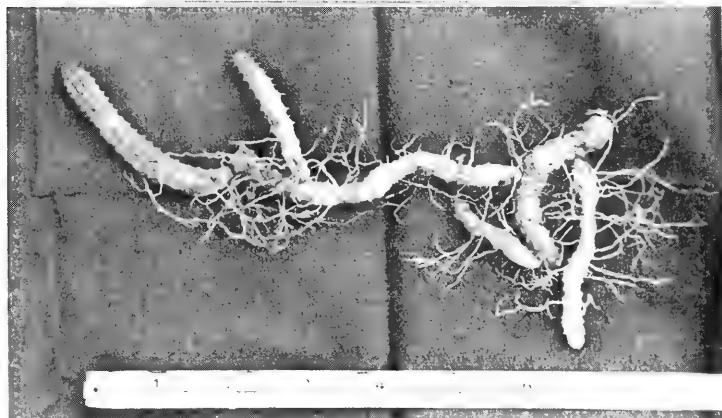
Type: South Africa, Cape Prov., *Leach & Bayliss* 13612 (K; PRE, holotypus).

South Africa, Cape, 3324 (Steytlerville), near the eastern end of Baviaans' Kloof (-DA), fl. 30. xii. 1966, and later in cult. at Nelspruit, *Leach & Bayliss* 13612 (K; PRE).

The east to west mountain ranges of the Cape seem to provide optimum conditions for speciation and this process appears to be taking place in *Huernia pillansii*; however, in this instance where the flowers of the two taxa appear



Plant from  
shaded  
situation



Plant from  
shales, on  
open hillside



A comparison:  
subsp. *pillansii*  
above

to be identical, it is considered that evolution has not proceeded far enough, despite the wide divergence in vegetative characters, to justify separation at specific level. The new subspecies has an apparently isolated distribution towards the eastern end of Baviaans' Kloof, where it has been found at several points, growing in Karroo shales both in shade and in the open.

Subsp. *echidnopsioides* may be easily distinguished by its tessellate, relatively few angled stems which are quite devoid of the characteristic bristles of the typical subspecies and by the underground rhizomatic habit which frequently develops.

*Plant* succulent dwarf, caespitose, in open situations in shales a rhizomatic underground habit develops with the above-ground portions of the plant then consisting of scattered, mostly simple, short stems. *Stems* more or less terete with an obtuse apex, c. 1 cm diam, up to 16 cm long, with 8—10, usually 9, vertically arranged (sometimes in a slow spiral), closely set rows of tessellate tubercles, sharply sulcate between the rows; *tubercles*, 1—2 mm high with a small knob-like protruberance at the apex, 2·5—5 mm apart longitudinally (closer towards the apex of the stems).

Otherwise as the typical subspecies.

#### ACKNOWLEDGEMENTS

The author is much indebted to:

Col. R. D. Bayliss for many plants, photographs and material of the *Stapelieae* from various regions of South Africa.

Dr. L. E. Codd, Chief, Botanical Research Institute, Pretoria, and his staff, for the facilities of the herbarium and much other assistance.

The Director, Royal Botanic Gardens, Kew, for Verifax copies of some relative descriptions of *Stapelieae*.

The Directors of, The Bolus Herbarium, Cape Town (BOL); The Botanical Research Institute, Grahamstown (GRA) and The National Botanic Gardens, Kirstenbosch (NBG), for the loan of material.

## SOME NOTES ON THE INTERNAL ANATOMY OF LITHOPS: II†

CHESTER B. DUGDALE

(Fairleigh Dickinson University, Rutherford, New Jersey, U.S.A.)

The only drawing of the internal anatomy of a Lithops plant known to me is that found in G. C. Nel's LITHOPS. The drawing presented here is a composite based upon the microscopic examination of hundreds of sections of both fresh and preserved plants of many different species. The general outline of the drawing and the general internal plan were adapted from a freshly-cut *L. turbiniformis*, but the photomicrographs were taken from a variety of species. Since there appears to be a universality of cellular structure within the genus, these photomicrographs are not identified as to the species which they actually depict. Each picture was selected only for its value in illustrating a particular area of the general plan.

As was stated in Part I of this series, this study is being pursued in the hope that information of taxonomic value will be found in addition to the knowledge of the cellular anatomy of Lithops plants. At present it appears that if such knowledge is obtained, it will probably be derived from the further study of the tanniniferous idioblasts since they appear to be the only variable elements in an otherwise quite generalized (i.e. genus-wide) cellular construction. For the purpose of learning more about the idioblast patterns, a group of Lithops plants have been collected by the author at some 35 habitat sites in South Africa and are currently being studied. More, either living or preserved, are needed.

### ACKNOWLEDGEMENTS

This work has, in part, been made possible by a Fairleigh Dickinson University Research Grant and by funds received from the Cactus and Succulent Society of New Jersey and the New York Cactus and Succulent Society. Furthermore, deepest gratitude is herewith conveyed to those several friends in South Africa and the U.S.A. who made the field collecting trip in March–April, 1967, possible and so successful.

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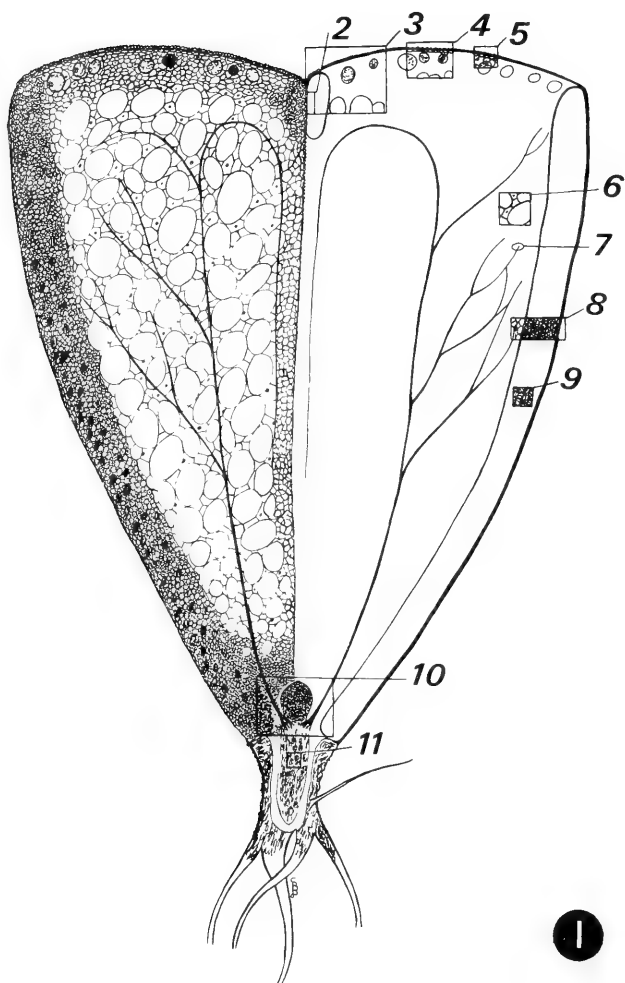


FIG. 1  
Generalized *Lithops* plant body, median l.s.

del. C. B. Dugdale

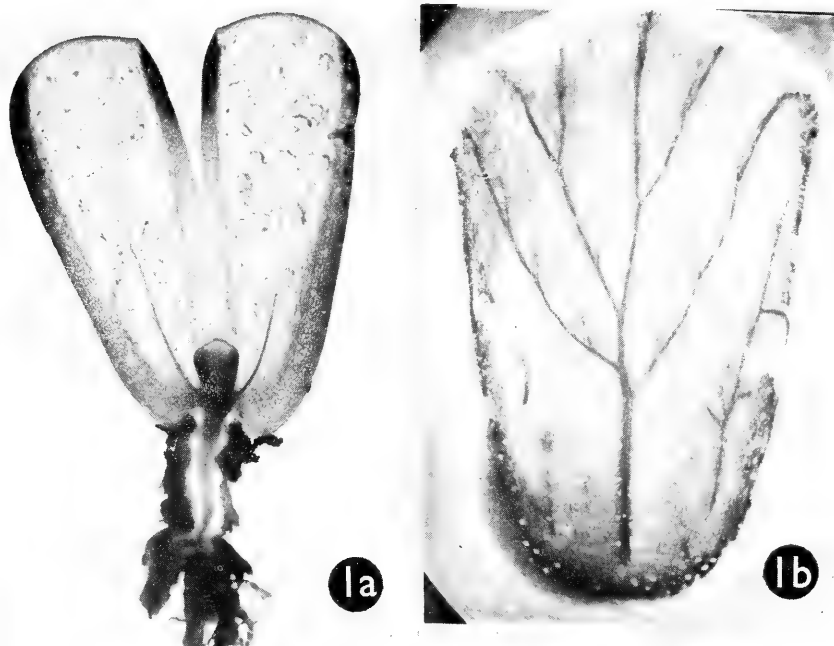


PLATE 1a.

A macrophotograph of a fresh *L. helmutii*, xi, (The image on the negative was the same size as the specimen.) There is, of course, a greater separation between the leaves than in *L. turbiniformis* and there are more chlorenchymatous cells to be seen on the adaxial walls, but the general plan is similar to that shown in the drawing. The root-stem complex and the new set of developing leaves are noteworthy.

PLATE 1b.

This shows the vascular system in a leaf treated by the technique described in Part II of this series, x5. The plane of this picture is at right angle to the plane of the drawing and the vascular bundles are seen overlying the chlorenchyma, beneath which lies the unseen inside of the epidermal layer.

PLATE 2.

A prepared and stained section of two lithops leaves showing the fissure between them, x430. Most noteworthy are the epidermal cells seen interdigitating with those of the opposite leaf. See also the layer of quite regular brick-shaped cells which are consistently found underlying the epidermal layer. These cells will hereafter be referred to as the epidermal base layer.

PLATE 3.

A view of the upper left corner of the drawing, x100. The epidermal base layer supporting the epidermis is again present. Two complete, plastid-type, tanniniferous idioblasts are shown, as well as a fragment of a third. Note the dark nucleus-like body in the lateral idioblast of this plate and also in plate 5(b). Large water-storing cells are seen in the lower portion of the picture.

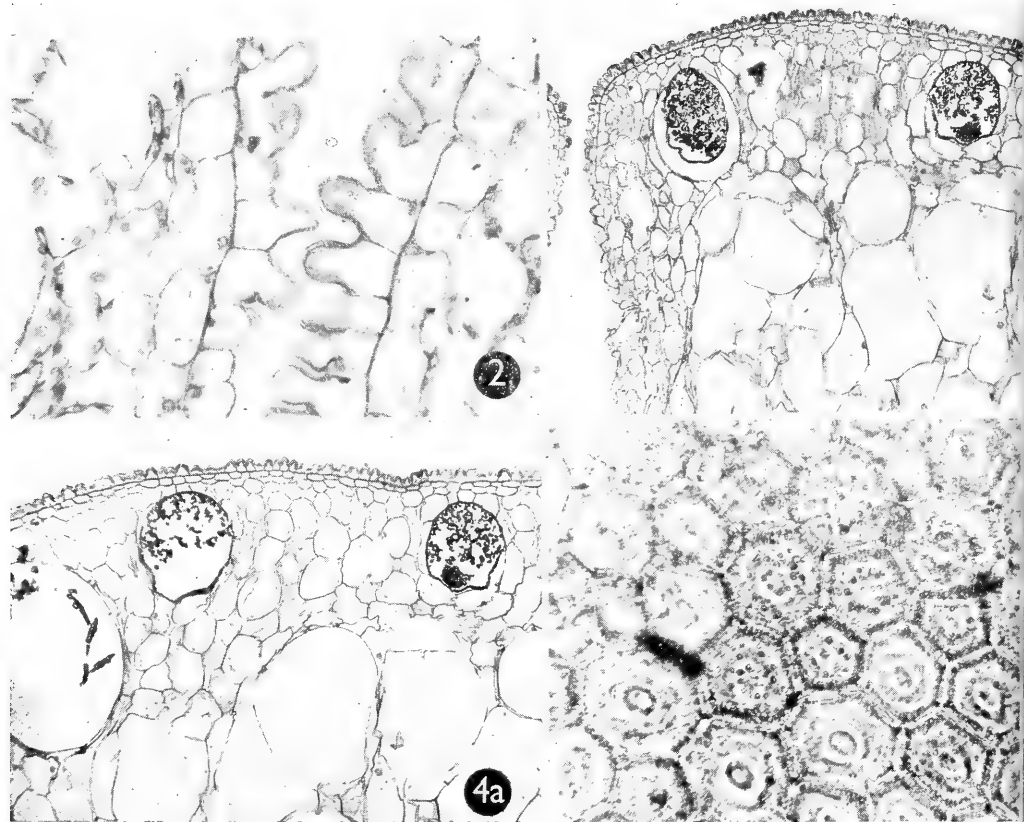


PLATE 4a.

A continuation of plate 3 showing more of the upper portion of the leaf, x100.

PLATE 4b.

A view of the underside of the epidermal layer showing the chromoplasts, x430. Fresh material, hand cut by razor blade.



PLATE 5a.

The upper half of a tanniniferous idioblast and the cells lying between it and the epidermis, x430.

PLATE 5b.

Detail of the nucleus-like portion of a tanniniferous idioblast, x430.

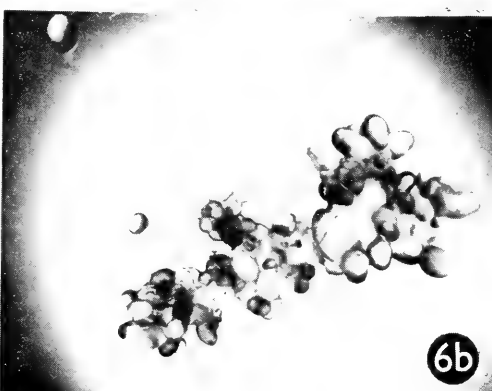
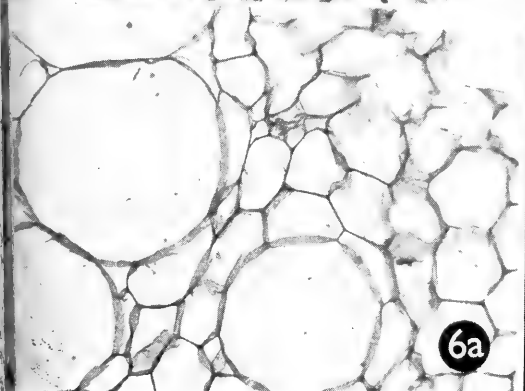
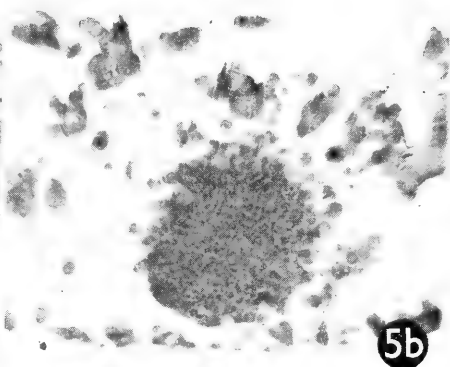
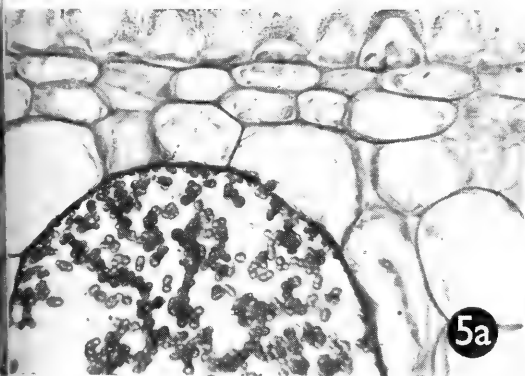


PLATE 6a

A section of the central core of the leaf showing the water-storage parenchyma and surrounding cells, x430.

PLATE 6b.

A cluster of water-storage parenchyma cells removed from a diseased and disintegrating leaf, x10. When a lithops leaf begins to rot and its central core becomes mushy, the water-storing cells are the last to be affected. Since the surrounding cells decompose first, scores of these intact water cells can be scooped out of the leaf with an appropriate instrument.

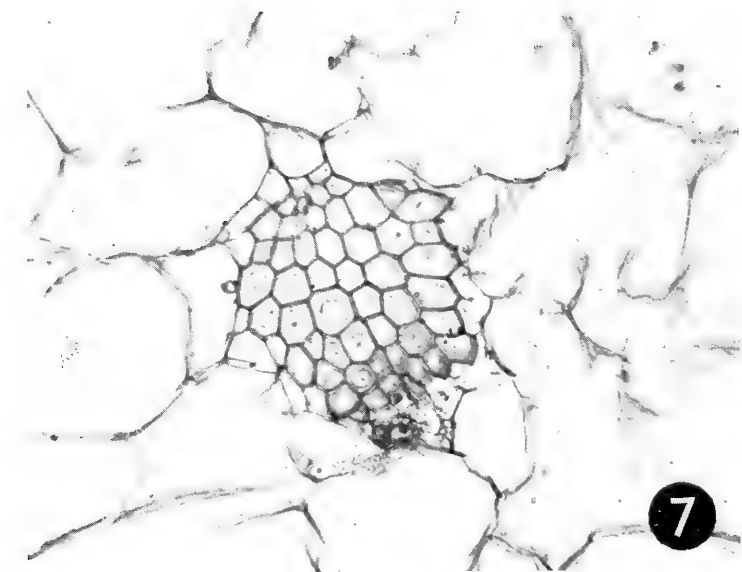


PLATE 7.

A cross-section of a vascular bundle, x430. Note the thickness of the walls of the xylem cells and the relative scarcity of phloem cells.

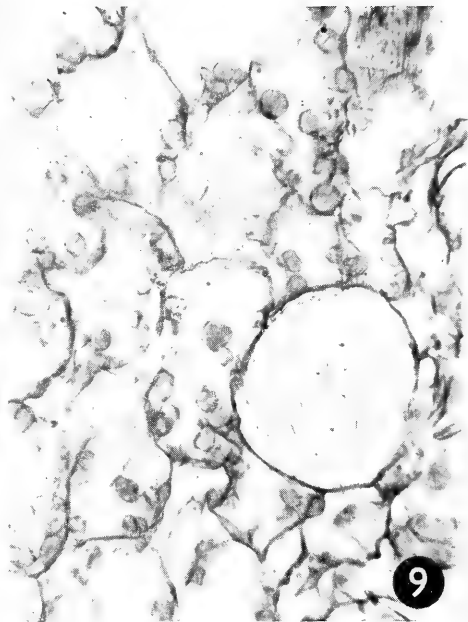
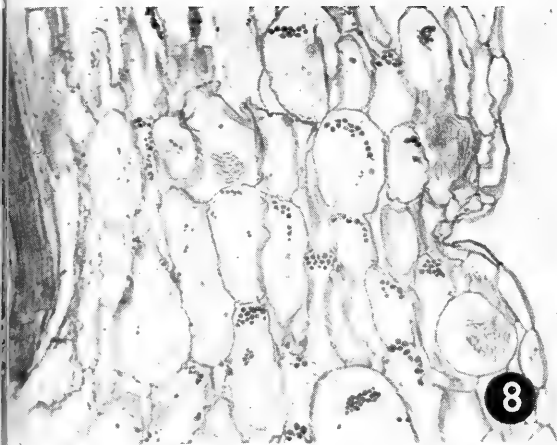
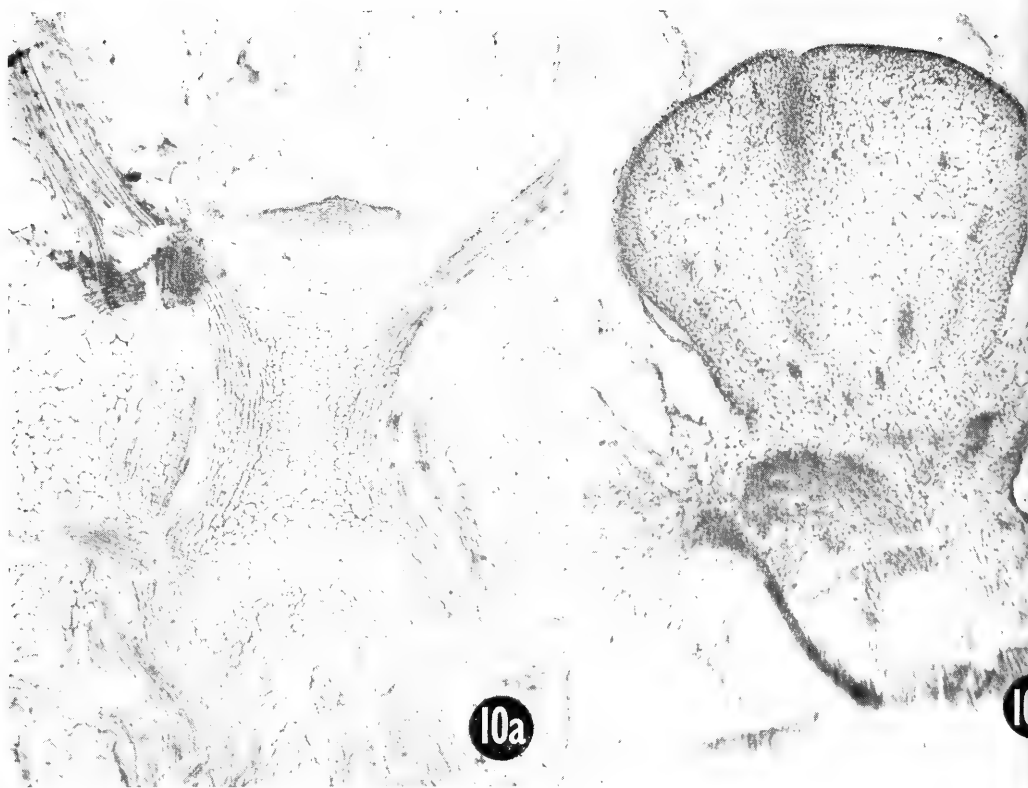


PLATE 8.

A section of chlorenchyma, x100. Included are several cells containing calcium oxalate raphides and a short length of a vascular bundle. In the fresh whole leaf the raphides are seen as glistening white specks which are more numerous in the area just beneath the epidermis as opposed to deeper within, and also they are more numerous toward the root as opposed to higher up.

PLATE 9.

Detail of chlorenchyma cells and a raphide cell, x430



PLATES 10 a and b.

Two views of the region where the root, stem, and leaf conjoin, x100. Plate 10 (a) shows the meristematic region and (b) the leaf primordia.

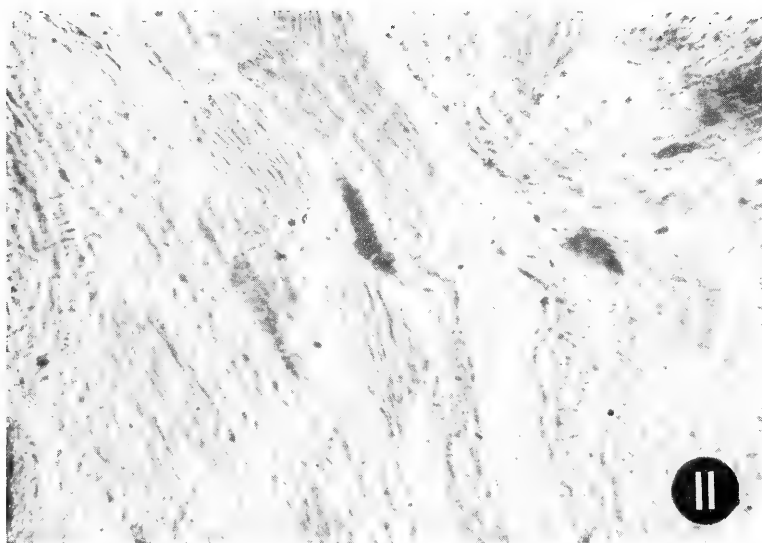


PLATE 11.

A portion of root tissue, x430. The major cellular components of this region appear to be calcium oxalate raphide cells and xylem vessels. I have so far found no particular pattern of organization of these elements.



# STUDIES IN THE XYLARIACEAE: III.

## SOUTH AFRICAN AND FOREIGN SPECIES

### OF *HYPOXYLON* SECT. *ENTOLEUCA*†

P. MARTIN

(*South African Institute for Medical Research, Johannesburg*)

#### INTRODUCTION

The South African species of *Rosellinia* and *Hypoxylon* have received scant treatment, the only authoritative work being that of Miller (1942) based on the collection at the National Herbarium, Pretoria. For the past eight years the writer has had opportunity to examine material from this country and from overseas, and to study in detail representative members within various species groups. This paper concerns the non-coloured species of *Hypoxylon*, many of which were formerly placed in *Rosellinia*.

#### METHODS AND MATERIALS

##### I. *General Investigation.*

Both herbarium material and collected specimens were routinely investigated. Collected material that was still viable was also crushed in sterile distilled water on a slide, and the ascospores extracted while viewing the preparation microscopically, by means of a micropipette. Spores were sown onto the surface of 2% malt agar plates with streptomycin. By viewing the agar surface through the reverse of the plate under the microscope it was possible to keep track of germinating spores and to distinguish them from contaminants. Pure cultures were eventually obtained. Descriptions of the cultures were made chiefly using plate and bottle cultures. Two per cent malt agar was used as the chief medium because preliminary experiments showed that the fungi grew on this with greater

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†Accepted for publication. 21st March, 1967.

luxuriance than on other media and showed differences from each other that could be expressed in precise terms. At least 15 and usually 20—25 plate cultures of each strain were examined in order to make a description of the external characters. These cultures were incubated at 5 temperatures, 15°, 20°, 25°, 28° and 31°C, and observations were made 3—10 days after, depending on the rate of growth of the colony. Duplicate and often triplicate cultures were also prepared using three other media, Leonian's, Czapek—Dox agar and maize agar, prepared according to formulae cited by McLean and Cooke (1941) and Wehmeyer (1924).

Each strain was also cultured in 8-oz medicine bottles of all four media. Malt cultures were given greater emphasis in that several replicates were prepared. The bottle cultures were incubated at 25° for 14 days, after which they were systematically investigated, although observations were actually made after the first 7 days and continued for many months thereafter. Except where specifically mentioned all descriptions of the bottle cultures were based on their appearance when 14 days old.

In the species descriptions the behaviour of malt agar was taken as standard, and reference to other media made only in specific instances since the general characters on all media were found to be the same, and the chief differences between them mainly comprised degree of luxuriance only.

## II. *Terms used to express the growth characters of the mycelium.*

The following terminology was adopted from Long and Harsch (1918) and new terms have been added to express those growth characters not already described:

### A. *General Growth Character*

1. *Submersed*: Colony growing entirely below the surface of the agar; aerial mycelium none.
2. *Canescent*/  
    *Downy*: Aerial mycelium consisting of short fine hyphae, loosely scattered over the surface of the agar. In most of these colonies the majority of the growing hyphae are still below the agar surface, however.
3. *Felty*: Aerial mycelium matted, with intertwined hyphae resembling a thin felt; surface coarse or smooth.
4. *Cobwebby*: Aerial mycelium intermediate between felty and canescent; usually characterized by long weak intertwined hyphae lying in all directions.
5. *Silky*: Similar to the above, but the hyphae lie parallel, giving the appearance of combed silk.



6. *Cottony*: Aerial mycelium comprising a loose mass of erect rather long hyphae (3—5 mm.).
  7. *Velvety*: Aerial mycelium dense and usually rather compact in contrast to the above types; surface smooth resembling the "pile" of velvet due to many short, straight closely growing hyphae. The velvety appearance is usually enhanced by zonate growth.
  8. *Fleecy*: Aerial mycelium very dense though not necessarily very thick, opaque with the characteristic uneven surface similar to that of a fleece.
  9. *Lanose*/  
*Woolly*: Aerial mycelium forming a dense opaque mass, usually with a smooth surface; normally very thick (3—5 mms.), and consisting of long tortuous hyphae.
  10. *Floccose*: The aerial mycelium may be initially appressed velvety or fleecy, but is distinct in that scattered pulvinate or irregular patches of short mycelium arise all over the surface of the colony as it grows older.
- B. *Aspect*.
1. *Gelatinous*: The surface of the colony is smooth and to some extent shiny, resembling gelatine. A gelatinous surface is characteristic of some but not all submersed or canescent colonies.
  2. *Sodden*: The mycelium has a water-soaked appearance. The colony varies from appressed to velvety but is never fleecy or lanose.
  3. *Dry*: The opposite of that just described. It is characteristic of the great majority of the species investigated.
  4. *Appressed*: The aerial mycelium is very compact and tends to grow more or less parallel with the agar surface. This aspect is typical of canescent and velvety colonies.
  5. *Plumose*: Dry, with tufts of mycelium, particularly near the margin, that have a central core from which short hyphae radiate.
  6. *Zonate*: The aerial mycelium differs in character within the same colony, forming concentric zones of different degrees of luxuriance. Typical of velvety colonies.

### III. *Terms used to express the type of germination.*

When germinating spores were being observed through the reverse of the

agar plate on the compound microscope, a minor point of difference between species was observed in the manner of growth of the hyphae (Fig. II). In some species germ tubes appeared at irregular intervals through the germ slit and the branches from these radiated symmetrically, while in others the germ tubes arose more or less from the opposite apices of the spore and the branches proceeded irregularly. The first type is termed radiate and the second free-spreading.

#### IV. *The Problem of Spore Dimensions.*

Up to the present, most descriptions of species in the *Xylariaceae* given in Saccardo's *Sylloge Fungorum* and elsewhere, simply record a range of spore dimensions, rarely accompanied by an average measurement to the nearest micron. This lack of precision was the main stumbling block in identification of material for the present work. When the observed range of dimensions exceeded or overlapped the one recorded it was impossible to know whether the identification was correct or not. Confirmation by overseas authorities only partly solved the problem.

In recording spore dimensions for this work therefore, two items were therefore clearly determined:

A. the range of width and length to the nearest  $0.5\mu$ .

B. The average value of width and length to the nearest  $0.1\mu$ .

These were based on measurements of at least 10 spores per strain to the nearest  $0.75\mu$  or less.

#### V. *Abbreviations.*

The following abbreviations have been used for herbaria in this and succeeding papers:—

AA.: University of Michigan Herbarium, Ann Arbor, Mich., U.S.A.

CMI: Commonwealth Mycological Institute, Kew, Surrey, England.

FBLA: Forest Biology Laboratory, Calgary, Alberta, Canada.

FBLBC: Forest Biology Laboratory, Victoria, B.C., Canada.

FBLNB: Forest Biology Laboratory, Fredericton, N.B., Canada.

Mill: Miller Herbarium, Georgia Experiment Station, Experiment, Ga., U.S.A.

NFC: National Fungus Collection, Beltsville, Md., U.S.A.

NYBG: New York Botanical Garden, New York, U.S.A.

Pret.: National Herbarium, Pretoria, South Africa.

R.: Rijks Herbarium, Leiden, Holland.

#### ANALYSIS OF SPECIES

##### *South African Species.*

1. ***Hypoxylon corticium*** (Schw.) Martin comb. nov.

sub *Rosellinia corticium* (Schw.) Sacc. Ellis, J. B. & B. M. Everhart North Amer.

Pyren. 164, (1892), Saccardo, P. A. Sylloge Fungorum I, 253, (1882), Shear, C. L. Mycologia 33, 327, (1941).

sub *Rosellinia megaloeia* E. & E. Ellis, J. B. & B. M. Everhart Proc. Acad. Nat. Sci. Philad. III, 23, 128, (1893).

sub *Sphaeria corticia* (Schw.) Schweinitz, L. v.d. Schr. d. Naturf. Ges. Zu. Leipzig 1, 44, (1822).

Stromata globose to pulvinate, brownish-black, forming small glomerules  $1.2-2.2 \times 1.2-3.2 \times 1.2-3.0\mu$ , normally closely aggregated and embedded in dark matted subiculum of closely anastomosed reticulate or pseudoparenchymatous hyphae, but occasionally gregarious and lacking a subiculum (Plate I: 7). Outer ectostroma dull murky brown, merging with the carbonous layer of the entostroma; basal tissue soft, dark brown and usually fairly limited in extent. Perithecia 1—3 per stroma, globose, relatively large, occupying most of the interior of the stroma at maturity and also normally clearly evident externally,  $800-2,100 \times 800-1,500\mu$ ; ostioles papillate and usually prominent. Asci cylindric, short stipitate; ascus plugs constricted. Spores elongate—elliptic or navicular, inequilateral, dark brown to black; germ slits on the convex side. The perfect stage mainly differs from that of *H. aquilum* in the absence of spore apiculae.

There are two apparent varieties:—

- a) var *macrosporum* Martin, nov. var.  
 Asci  $230-275 \times 11-12\mu$ , stipes  $48-63\mu$ .  
 Spores  $9.5-13.5 \times 21.5-39.0\mu$ , ave.  $9.9 \times 26.5\mu$ .
- b) var *microsporum* Martin, nov. var.  
 syn. *Rosellinia megaloeia* E. & E.  
 Asci  $170-200 \times 6-10\mu$ , stipes  $37-50\mu$ .  
 Spores  $5.5-9.5 \times 12.5-25.5\mu$ , ave.  $7.5 \times 19.4\mu$ .

*South African Hosts: Royena lucida, Kiggelaria africana, Olea capensis, Maytenus buxifolia.*

*Material examined:*

sub *Rosellinia aquila*. A large quantity of material in the 'Rijks Herbarium. ex Cornell expedition det. Seaver; Labrador Lake, Ithaca, NY, U.S.A. (1919), (NYBG). Burke 9; Montgomery Co., Alabama, U.S.A. (1916), (NYBG).

sub *Hypoxylon corticium*. Martin 16, 22, 77, 316, 565, 1,029, 1,035; Nature's Valley, Knysna Dist., W. Cape, South Africa (1958, 1959, 1962). Martin 540, 544; Hogsback near Alice, Eastern Cape, South Africa, (1959). Martin 565; Highlands, Albany District, Eastern Cape, South Africa, (1959). Martin 588, 611; Los Angeles, S. Calif., U.S.A., (1961). Martin 949; Mazat-

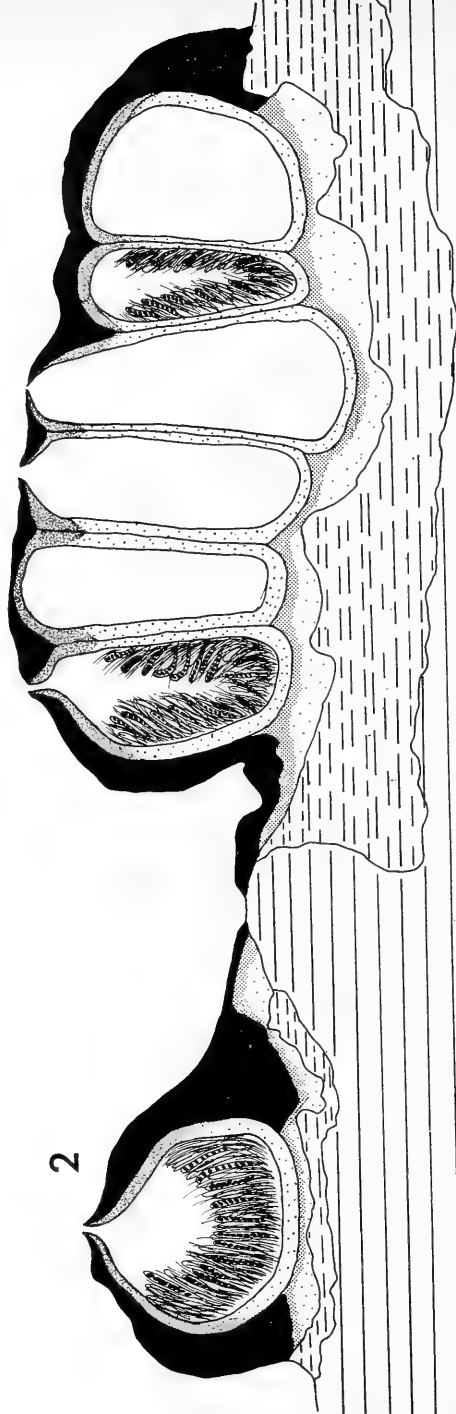
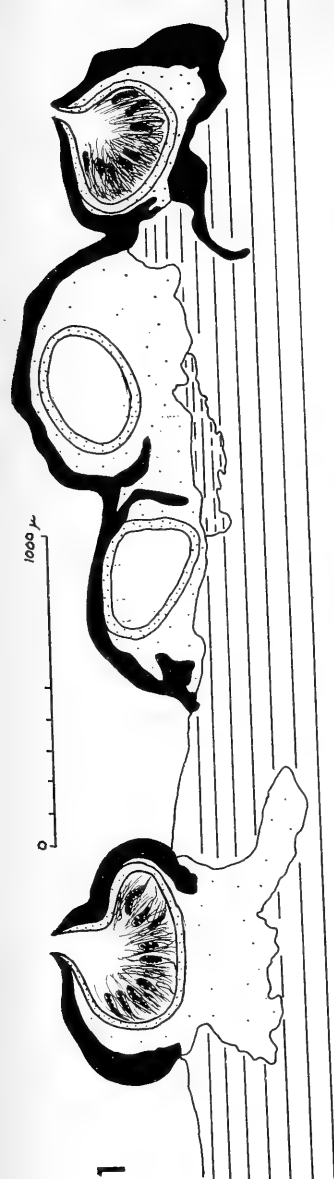


FIG. 1. Diagrammatic drawings of longitudinal sections through the stromata of:  
 1. *Hypoxylon discolor*.  
 2. *Hypoxylon smilacolum*.

1. *Hypoxylon discolor*.  
 2. *Hypoxylon smilacolum*.

Ilan, Sinaloa, Mexico, (1961). Martin 1179; Lake Ozark, Missouri, U.S.A., (1962). Martin 1625, 1627; Nyack Village, Rockland Co., NY State, U.S.A., (1963.)

*Cultural Characters* (Plate III: 3):

Germinating pattern free spreading. A rather thin dull white to greenish felt with a silky appearance is formed, later becoming somewhat cobwebby with loose mycelium up to 12 mm. high; with age the colonies sometimes become depressed in the centre while the marginal region remains luxuriant. Margin not distinct, felty, appressed, effuse, entire with widely dispersed peripheral hyphae. Stain absent; carbonization usually absent, but seen on Czapek bottle cultures after about 2 months old. Czapek cultures are less luxuriant than on malt. Growth on malt at 25°C is 4·80—7·90 mm./day.

*Microscopic Characters:*—

The primary mycelium is much broader than in previous species, the marginal hyphae having a maximum width of  $3\cdot1\mu$  (Fig. II: 5). Also there is a well developed secondary mycelium, composed of 2 main types of branching system, one composed of long filaments which branch repeatedly at right angles and interclasp and anastomose to form a felt of indefinite extent (Fig. II: 10) and another lying beneath the first which comprises stouter bulbous hyphae not so closely associated (Fig. II: 6). The first type of mycelium has a diameter of  $2\cdot3$ — $2\cdot9\mu$ , while the bulbous type is  $5\cdot4$ — $16\cdot6\mu$  in diameter.

The reticulate secondary mycelium and conidiophores produced in culture correspond exactly in organisation to the subiculum and conidiophores associated with the perfect stage. Mycelium resembling the subiculum of collected specimens was also produced by infecting twigs with primary mycelium of *H. corticum* and leaving them in the open near a stream in a shady kloof. After 3 months pulvinate masses of dark subicular mycelium were found along the bark of the twigs. The surface of the mycelium was covered with conidiophores agreeing with those found in association with the perfect stage of many collected specimens (Fig. II: 10). Conidiophores were not produced in culture *in vitro* by all strains.

The conidiophores often in contrast to the dark mycelium bearing them, are light coloured, and hyaline. They are determinate in growth but variable in length and each consists of a long stalk  $100$ — $1,080 \times 2\cdot3$ — $4\cdot5\mu$ , and a terminal multibranched portion giving rise to many fertile branches. These are usually fairly short,  $15$ — $52 \times 2\cdot3$ — $4\cdot5\mu$  with a fertile region  $6$ — $10\mu$ , and are unseptate. The conidia are acropleurogenous, densely clustered, and form spicate or almost capitate heads. They are sessile on geniculate projections, apparently without definite order; in size they are relatively large and oval

elliptic with truncate bases or sometimes pyriform, subhyaline, and very pale grey or greenish grey collectively,  $2.3-3.7 \times 4.5-10.0\mu$ , av.  $3.1 \times 6.8\mu$ .

## 2. *Hypoxylon aridicolum* Martin nov. sp.

It was impossible to find more than a small sample of this species so that the following description cannot be taken for a generalised account. It is clearly similar to *H. corticium* in possession of a subiculum and in general stromal characters. The perithecia are large globose,  $1,500-200 \times 1,200-1,700\mu$ . The difference between the two species lies in the spores which are elliptic with acutely pointed ends, inequilateral, usually light brown and measuring  $4.5-9.0 \times 14.0-24.0\mu$ , ave.  $6.8 \times 18.7\mu$ . The asci are cylindrical with fairly long stipes,  $140-150 \times 9\mu$ ; stipes  $30-60\mu$ .

### Material examined:

Martin 508; on *Schotia latifolia*, Fish River Valley near Grahamstown, Eastern Cape, South Africa, (1959).

### Cultural Characters:

Germination pattern free spreading. In colony characteristics this species resembles the preceding so closely in general features that no separate description seems necessary. Both bottle and plate cultures and the microscopic characters are identical in form and dimensions, but the following features are peculiar to *H. aridicolum*:—

1. There is no difference in growth of cultures on Czapek and on malt, whereas in *H. corticium* Czapek cultures are much less luxuriant.
2. No conidiophores have been developed in culture.
3. The growth rate on malt differs significantly from that of *H. corticium*, this species growing faster at all temperatures, and also having a higher temperature tolerance. Growth at  $25^{\circ}\text{C}$  is  $9.74$  mm./day.

## 3. *Hypoxylon perusensis* (P. Henn.) Martin comb. nov.

sub *Rosellinia perusensis* P. Henn. Hennings, P. Hedwigia 48, 10, (1908), Saccardo, P. A. Sylloge Fungorum XXIV, 837, (1926).

Stromata small, glomerular or pulvinate,  $0.5-5 \times 0.5-20 \times 0.6-1.5$  mm., often deep black and shiny, uniperitheciate, globose or with several perithecia under a superficial covering that closely follows their outline, pulvinate when the perithecia are closely associated (Plate I: 6). Ectostroma rudimentary, entostroma mostly carbonous, with soft basal tissue slight in quantity. Perithecia  $450-900 \times 650-1,400\mu$ ; ostioles indistinct, papillate. Asci narrowly cylindric,  $85-140 \times 6\mu$ , with stipes  $20-60\mu$ . Spores oval with rounded ends, pale brownish grey, subhyaline,  $3.0-6.0 \times 6.0-11.0\mu$ , ave.  $4.9 \times 9.3\mu$ .

*Material examined:* Martin 45, 76, 440; on *Passerina falcifolia*, Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959). Martin 256; wood unidentified, Alexandria Forest, E. Cape, South Africa, (1958). Martin 430; on *Maytenus buxifolia*, Nature's Valley, Knysna District, Western Cape, South Africa, (1959). Merrill; Flora Philippines 8,768 det. Sydow, Taytay, Palawan, Philippines, (1913), (NYBG).

*Cultural Characters* (Plate III: 1).

Germination pattern radiate. Colonies canescent, white subhyaline, with a moderately coarse surface. In old colonies in bottle culture and sometimes on plates very small superficial aggregates of mycelium lend the colony a characteristic granulate appearance. Margin submersed, hyaline and colourless, in some cases entire, in others lobed or segmented, peripheral hyphae dispersed. Stain and carbonization none. Growth at 25°C slow, 1.95 mm./day.

*Microscopic Characters:*

Primary mycelium with no distinguishing character, marginal hyphae with a maximum diameter of 2.0 $\mu$ ; secondary mycelium nil.

4. *Hypoxylon ravenelii* Rehm.

Ellis, J. B. & B. M. Everhart, Jour. Mycol. **4**, 111, (1887), Ellis, J. B. and B. M. Everhart, North Amer. Pyren., 655, (1892), Rehm, H. Hedwigia **21**, 136, (1882).

Stromata uniperitheciate and globose or multiperitheciate and pulvinate, but rarely with more than 6 perithecia per stroma, 0.6—1.9 $\times$ 0.6—4.8 $\times$ 0.6—1.3 mm., shiny black, often with a circular indentation in the surface near the vertex of each perithecial outline (Plate I:3). The perithecia are globose, 400—900 $\times$ 600—1,100 $\mu$ . Asci cylindric with short to moderately long stipes, 105—115 $\times$ 6 $\mu$ , stipes 25—50 $\mu$ . Spores oval, equilateral with rounded ends, pale amber yellow, 4.0—7.0 $\times$ 8.0—13.0 $\mu$  ave. 4.8 $\times$ 10.3 $\mu$ .

This species is close to *H. chrysoconium* B. & Br. in stromal form.

South African hosts include: *Canthium spinosum*, *Cassine croseum*, *Tarchonanthus camphoratus*.

Wood and bark are usually densely infested. Often the pearly white initial stage is innate in the substrate as in members of *Anthostomella*, and the stroma becomes superficial only towards maturity, due to attrition.

*Material examined:* Chrisfield in Miller Herb. 3397, Savannah, Ga. U.S.A., (1929), (Mill.) Martin 332, 367, 369, 428, 434, 435, 438, 439, 461, 506; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959).

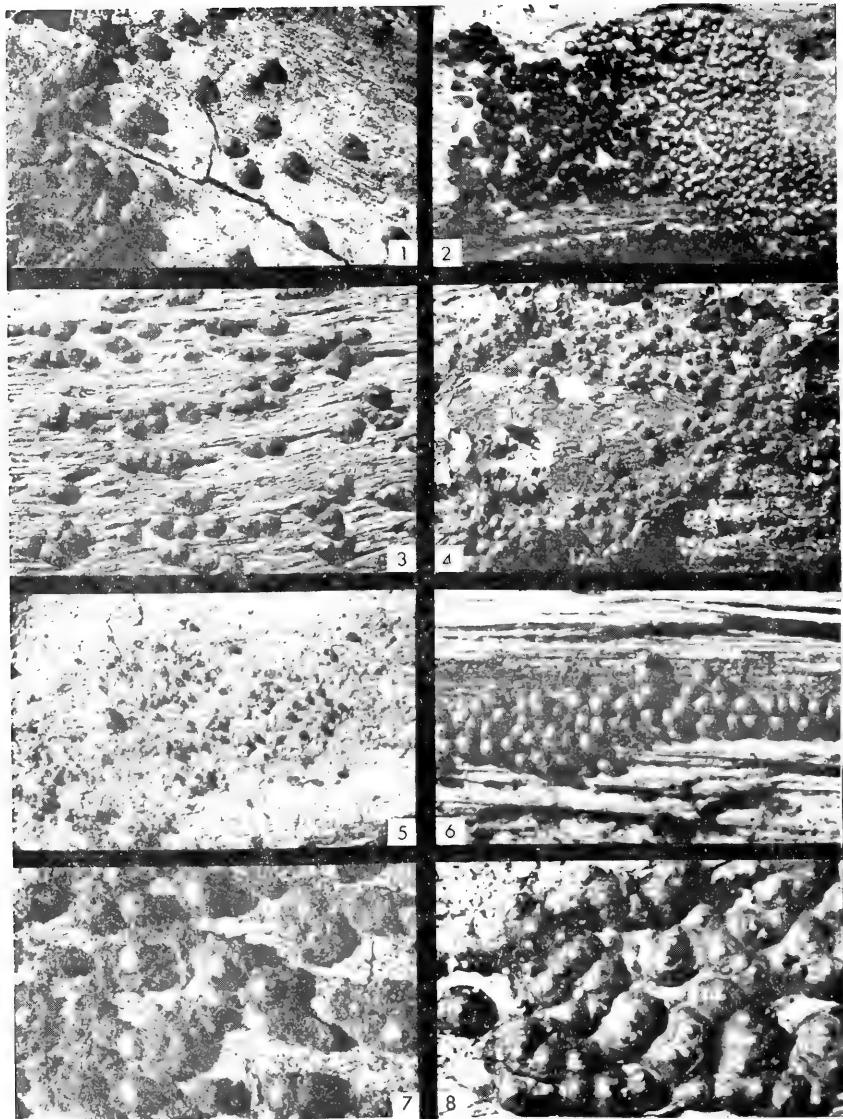


PLATE I. Stromata.  
1— $4 \times 2.8$ , 5— $8 \times 3.5$

1. *Hypoxylon mastoideum*.
2. *Hypoxylon chrysoconium*: immature stage at right.
3. *Hypoxylon ravenelii*.
4. *Hypoxylon entoleucum*.
5. *Hypoxylon minutissimum*.
6. *Hypoxylon perusensis*.
7. *Hypoxylon corticium*.
8. *Hypoxylon adumbratio*.



*Cultural Characters* (Plate III: 2).

Germination pattern radiate. Colonies mainly submersed to canescent, with sparse closely appressed white subhyaline aerial mycelium that is not more than 0.2 mm. high. Surface at first smooth, then with a characteristic coarse granulate surface. Margin submersed, almost colourless, entire, peripheral hyphae compact to somewhat dispersed. Conidia none. Stain variable, sometimes absent altogether but normally apparent after 14 days, at first light orange brown or amber yellow, then deepening to dull brown with age. Growth at 25°C moderate, 3.78 mm./day.

Cultures on maize and Czapek are less luxuriant, submersed except for scattered silky plumose filaments near the margin, and with a sodden aspect.

*Microscopic Characters:*

Primary mycelium with no distinguishing character, marginal hyphae with a maximum diameter of 1.5  $\mu$ . No secondary mycelium.

5. *Hypoxylon serpens* (Pers. ex Fr.) Kickx.

Dennis, R. W. G. British Cup Fungi. 178, (1960), Kickx, J. Flora Crypt. Louvain. 115, (1835), Miller, J. H. Jour. Dept. Agric. Puerto Rico. 14, 273, (1930), Miller, J. H. Trans. Brit. Mycol. Soc. 15, 141, (1930), Miller, J. H. Mycologia. 25, 327, (1933), (var. *macrosporum*), Miller, J. H. Monog. Univ. Puerto Rico. B, 2, 206, (1934), Shear, C. L. Mycologia. 20, 87, (1928).

sub *Sphaeria serpens* Pers ex Fr. Fries E. M. Systema Mycologicum 341, (1823), Persoon C. H. Observationes Mycologicae, 18, (1796).

Stromata uniperitheciolate and semicircular, or multiperitheciolate and pulvinate to slightly effuse 0.6—21  $\times$  0.6—75  $\times$  0.3—1.7 mm., always superficial on bark or decorticated wood, grey to dull black in colour. Ectostroma evanescent and merging eventually with the carbonous entostroma that forms the bulk of the stroma; basal tissue pale, uncarbonised, small in quantity and closely following the line of the perithecial bases. Perithecia large, broadly globose, occupying most of the stromal interior, and evident in outline, 500—1400  $\times$  450—900  $\mu$ ; large and small perithecia occur in the same stroma but usually those developing singly in a stroma are larger (1000—1400  $\times$  650—900  $\mu$ ) than those developing severally (500—650  $\times$  450—730  $\mu$ ). The perithecial wall is uncarbonized except for the ostioles and is often very difficult to distinguish from the surrounding tissue. The ostioles are typically papillate and sometimes spout shaped. In most cases a layer of ectostroma clearly forms the outer part of the ostiole; in others this layer is very thin. Asci clavate or cylindric, usually long stipitate, 81—215  $\times$  5—10  $\mu$ , stipes 24—90  $\times$  2  $\mu$ . Spores

elliptic with rounded ends, slightly inequilateral, characteristically amber but also pale brown or brownish grey and subhyaline, or more rarely dark brown and opaque,  $3.5-8.5 \times 8.0-22.5\mu$ , av.  $5.4 \times 13.2\mu$ .

This writer regards *H. caries* as merely a small spored form of *H. serpens* and the distinction made by Miller (1961, pp. 80 and 81) between *H. serpens* normal type and the two varieties *var. effusum* and *var. macrospora*, to be of doubtful value, since there was usually a wide range of stromal form and spore size to be found within each example collected by the writer. Cultural work supports this view, there being no essential difference in character of a large number of strains.

*Material examined:* A large number of specimens in the IMI, Rijks & New York Herbaria: Martin 119, 280, 462, 483, 484, 495, 522, 524: Nature's Valley, Knysna District, Western Cape, South Africa (1958, 1959). Martin 227, 228, Hogsback, near Alice, Eastern Cape, South Africa (1958). Martin 272, 278; Alexandria Forest, Albany District, Eastern Cape, South Africa, (1958). Martin 660, 685; Yosemite National Park, California, U.S.A., (1961). Martin 696, 697, 713, 714, 715, 724, 725; Klamath, Northern California, U.S.A., (1961). Martin 739, 740, 741-756, 763, 780, 788; O'Brien, Northern California, U.S.A., (1961). Martin 792; Arcata, Northern California, U.S.A., (1961). Martin 1094; Columbia, Missouri, U.S.A., (1962). Martin 1132, 1145, 1146; Lake Ozark, Missouri, U.S.A., (1962). Martin 1533, 1576; San Blàs, Nayarit, Mexico, (1962). Martin 1599, 1615; Rockland County, New York State, U.S.A., (1963). Martin 1695; Conway State Forest, Mass., U.S.A., (1963). Martin 1704; Mt. Toby, Massachusetts, U.S.A., (1963). Martin 1767; ex Carroll, Univ. of Costa Rica Botanical Garden, San Pedro, Costa Rica, (1963). Martin 1800; ex Carroll, Kongedal, Sjaelland, Denmark, (1963).

*Cultural Characters* (Plate III: 4):

Germinating pattern free spreading. Colonies mainly submersed, with scant aerial closely appressed or canescent aerial mycelium which is usually hyaline and nearly colourless but white and opaque if occasionally developing in some quantity. Normally conidia are found abundantly soon after inoculation, so that the entire surface becomes characteristically fine granulate and ashy grey. In some cases however, where the conidia fail to develop, the mycelium has a sodden colourless aspect. Growth is normally uniform but sometimes ill defined zones 4-6 in number and 5-6 mm. wide appear, differing only in the concentrations of superficial conidia. The margin is usually distinct due to the absence of conidia, submersed, hyaline, colourless and entire; peripheral hyphae compact and closely parallel. Stain and carbonization none. Growth

at 25°C very slow to moderate, 0.71—3.10 mm./day. Cultures on maize are less luxuriant and Czapek cultures grow extremely poorly, submersed with a sodden aspect.

*Microscopic Characters:*

The primary mycelium has a maximum diameter of  $2.9\mu$ , and an interesting though inconsistent feature is the undulating form of the marginal hyphae. Secondary mycelium nil.

*Conidiophores and conidia:*

The conidiophores comprise an indefinitely branched system  $180\text{--}1050 \times 1.2\text{--}3.0\mu$  of which the terminal hyphae and parts of the main branches of the mycelium are fertile. The branches arise from over the length, or at least the upper half of, the primary axes. Apart from the production of conidia, the conidiophores can often be distinguished from the vegetative mycelium by ternate branching and are usually variable in length,  $4\text{--}128 \times 1.6\text{--}4.3\mu$ . The fertile hyphae are geniculate, and either bear conidia along short spicate terminal portions, or in apical clusters. The latter clearly represents a shortening of the fertile axis. The conidia are sessile, usually borne in 4 rows corresponding to the outward elongation of the tip of the fertile hyphae in 4 different directions, but may also be borne without apparent order. They are small, equilateral oval, with both ends rounded or with truncate bases, hyaline individually but deep cineraceous grey when seen collectively, and measure  $1.4\text{--}3.1 \times 2.5\text{--}6.3\mu$ , ave.  $2.4 \times 3.6\mu$ .

6. *Hypoxylon cuneosporum* Martin, sp. nov.

Stromata aplanopulvinate or globose,  $1.8\text{--}4.4 \times 1.9\text{--}20 \times 0.7\text{--}1.2$  mm., superficial on bark or wood, but normally the former (Plate II:5). Surface of stroma smooth, dull black. Carbonous layer of the entostroma predominant, basal tissue well developed at maturity, corky, white and usually conspicuous. Perithecia globose,  $300\text{--}400 \times 500\text{--}600\mu$ , ostioles papillate and usually clearly visible on the surface of the stroma. Asci cylindric, usually long stipitate,  $90\text{--}150 \times 6\mu$ , stipes  $35\text{--}75\mu$ . Spores oval, inequilateral with one end slightly conical, pale brown,  $3.5\text{--}7.0 \times 9.5\text{--}14.5\mu$ , ave.  $5.0 \times 11.7\mu$ .

South African Hosts: Primarily *Olea capensis*, also occasionally other species unfortunately unidentifiable.

This species is close to *H. serpens* but differs in the greater development of basal tissue, and in the rather peculiar subconical spores.

*Material examined:* Martin 302, 345, 513, 514; Nature's Valley, Knysna District, Western Cape, South Africa (1958, 1959).

*Cultural Characters* (Plate III: 8):

Germination pattern free spreading. Colonies at first submersed for the first 10 days of growth then sparingly canescent, white subhyaline. Margin distinct submersed, entire, some 2—3 mm., broad, sometimes gelatinous in aspect, with compact peripheral hyphae. Conidia abundant, greenish-grey, produced almost immediately, certainly before the colony is a week old. Stain and carbonization none. Growth at 25°C very slow, 0.93 mm./day.

*Microscopic Characters:*

Primary mycelium not diagnostic; maximum diameter of the marginal hyphae =  $2.1\mu$ . No secondary mycelium.

*Conidiophores and conidia* (Fig. II: 18):

Conidiophores not clearly distinct from the vegetative mycelium except for the ternate branching;  $100\text{--}150\mu$  long and  $2.0\mu$  wide. The fertile branches are long, uniseptate,  $40\text{--}65 \times 1.5\text{--}2.1\mu$ ; fertile part rather indefinite in extent, occasionally divided by an intercalary sterile portion but usually occupying  $1/5\text{--}3/5$  of the fertile branch and ranging from  $10\text{--}40\mu$  in length. Conidia mainly pleuogenous, sessile, borne singly or on geniculate protrusions, and arranged spirally in 4 rows. They are hyaline, greenish-grey *en masse*, oval, with both ends rounded,  $1.4\text{--}2.3 \times 2.6\text{--}4.6\mu$ , ave.  $1.9 \times 3.3\mu$ .

7. *Hypoxylon quadratum* (Schw.) Ell. & Ev.

Ellis, J. B. & B. M. Everhart N. Amer. Pyren. 631, (1892), Miller J. H. World Species of *Hypoxylon* 61, (1961).

sub *Hypoxylon kellermanni* Rehm. Rehm, H. Ann. Mycol. 6, 313, (1908).

sub *Hypoxylon regale* Morgan. Miller J. H. Mycologia 25, 328, (1933), (var. *macrosporum*), Miller, J. H. World Species of *Hypoxylon* 67, (1961). Morgan, A. P. Journal of Mycology 10, 162, 1904.

sub *Sphaeria quadrata* Schw. Schweinitz, L. v.d. Trans. Amer. Phil. Soc. Philad. 4, 194, 1832.

Stromata pulvinate globose, 1—3 mm. wide or long and 3—4 mm. high, formed superficially on bark only (Plate II: 6). Surface of stroma smooth, grey-brown to black, normally dull but sometimes shiny with extreme age. Entostroma mainly carbonaceous and very thick; basal tissue corky, rather slight, conspicuous up to maturity but disintegrating with age. Perithecia 2—5 per stroma and occupying most of it,  $530\text{--}600 \times 700\text{--}800\mu$ ; ostioles indistinctly papillate. Asci cylindric or clavate, with stipes of moderate length,  $125\text{--}200 \times 10\text{--}18\mu$ , stipes  $25\text{--}70\mu$ . Spores oval with rounded ends, dark brown,  $8.0\text{--}14.5 \times 16.5\text{--}29.5\mu$ , ave.  $10.4 \times 21.9\mu$ . The writer regards *H. regale* and *H. quadratum* as identical, as the former separation based on spore size is too unreliable.

South African Hosts: *Olea capensis*

*Material examined:*

sub *Hypoxylon argillaceum* Morgan; on *Fraxinus*, Miami Valley, Ohio, U.S.A., (1894), (NYBG).

sub *Hypoxylon quadratum* Martin 21, 122, 225, 286, 1008, 1052; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1962). Miller 4906, = Morgan 6061; on *Fraxinus*, U.S.A., (Mill.).

sub *Hypoxylon regale* Miller; on *Quercus*, Mountain City, Georgia, U.S.A., (1929), (Mill.).

*Cultural Characters* (Plate III: 7):

Germination pattern free spreading. Colonies submersed at first, sometimes for a considerable time, later canescent and appressed, colourless and almost hyaline. Margin entire and compact. Conidia produced after 32 days in bottle culture, absent from plate culture, forming a thin greenish-grey superficial mat. Stain dark purple in bottle culture, absent from plate culture. Growth at 25°C very slow, 1.09 mm./day. Cultures on maize, malt and Leonian's agars are grossly similar, but cultures on Czapek remain almost completely submersed and have a gelatinous surface.

*Microscopic Characters:*

Primary mycelium undiagnostic. Maximum diameter of the marginal hyphae = 2.0  $\mu$ . No secondary mycelium.

*Conidiophores and conidia* (Fig. II: 19):

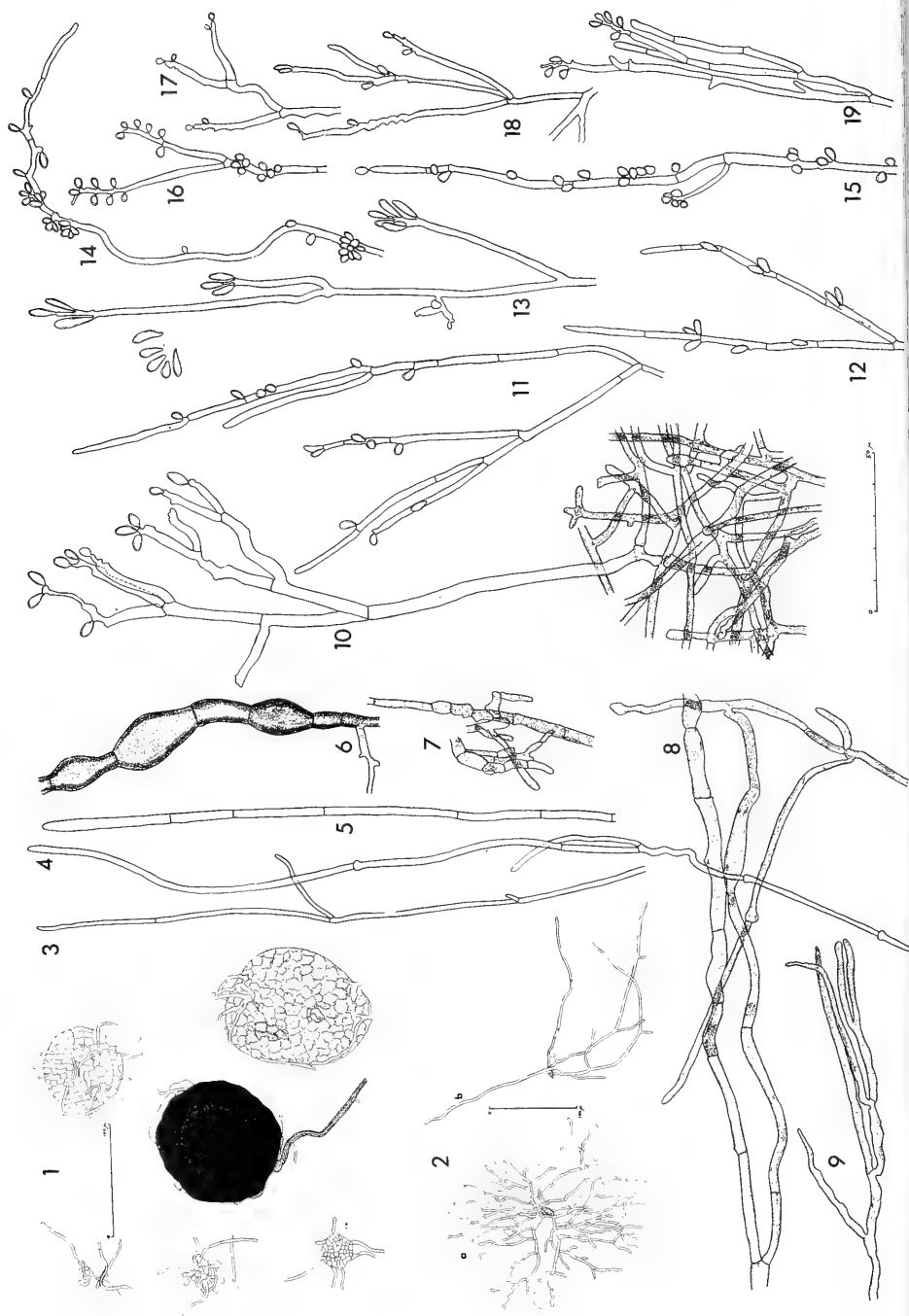
Conidiophores not clearly distinct from the vegetative mycelium, indefinitely dichotomously branched, 100—150  $\times$  2.0  $\mu$ ; fertile branches relatively short, 26—40  $\times$  2.0—2.5  $\mu$ , geniculate, normally unseptate but sometimes with one or two septae. Conidia acropleurogenous, each seated on a geniculate protrusion, apparently in spiral formation in 2 rows, subglobose to spherical, fawn-grey collectively, 2.0—2.9  $\times$  2.6—3.7  $\mu$ , ave. 2.5  $\times$  3.1  $\mu$ .

8. *Hypoxylon smilacicum* (Schw. ex Fr.) Howe.

Ellis, J. B. & B. M. Everhart Jour. Myc. 4, 70, (1887), Ellis N. Amer. Pyren. 642, (1892), Howe, E. C. Bull. Torrey. Bot. Club. 6, 31, (1875), Miller, J. H. World Species of *Hypoxylon*, 70, (1961).

sub *Sphaeria smilacicola* (Schw. ex Fr.) Fries, E. M. Elenchus fungorum 11, 71, (1826), Schweinitz, L. Trans. Amer. Phil. Soc. Philad. N.S. 4, 196, 226, (1832).

Stromata very small, pulvinate or globose, uniperitheciate or more commonly multiperitheciate, but with complete immersion of the perithecia



in the stroma;  $0.4-1.5 \times 0.4-4.5 \times 0.4-0.7$  mm. (Plate II: 1, 2). Colour dull black, never shiny. Outer entostroma a thin carbonous crust; basal tissue fairly well developed, light brown (Fig. 1: 2). Perithecia ovoid or conic, often flattened by mutual pressure,  $170-400 \times 350-550\mu$ ; ostioles indistinctly papillate. Asci clavate, short stipitate,  $100-130 \times 9-10\mu$ , stipes  $25-40\mu$ . Spores oval elliptic, slightly inequilateral,  $4.5-8.5 \times 11.0-17.5\mu$ , ave.  $6.9 \times 15.5\mu$ .

South African Hosts: Wood, unidentifiable but probably monocotyledonous.

*Material examined*: Howe; on dead *Smilax*, Yonkers, N.Y. State, U.S.A.

In Herb. Leroy, (pre 1898), (NYBG). Martin 396; Highlands, Albany District, E. Cape, South Africa (1959).

#### *Cultural Characters* (Plate IV: 9):

Germination pattern free spreading. Colonies at first (up to 7 days) finely canescent with scant subhyaline white aerial mycelium and a silky aspect especially near the margin, later becoming denser. Bottle cultures are weakly zonate or uniform, plate cultures strongly zonate, each zone 2 mm. wide and 5—7 mm. apart, consisting of an undulating irregular ridge of velvet white mycelium bearing sparse conidia. The central zone is the most regular and conspicuous. The mycelium between the zone is almost hyaline and closely appressed. The general surface of the colony is smooth or undulating and tends to be slightly gelatinous in aspect. Margin distinct, 4—13 mm. wide, submersed appressed, irregular and characteristically segmented, each segment 5—15 mm.

FIG. II. Mycelial Characters and Imperfect Stages.

1. *Hypoxylon entoleucum*: Stages in development of carbonous sclerotia.
2. Germination patterns: a) radiate: *Hypoxylon mastoideum*.  
b) free spreading: *Hypoxylon entoleucum*
- 3—5. Marginal hyphae, showing differences in diameter.
3. *Hypoxylon entoleucum*.
4. *Hypoxylon albocinctum*.
5. *Hypoxylon corticium*.
- 6—9. Types of secondary mycelium.
6. *Hypoxylon corticium*: bulbous hyphae within reticulate system.
7. *Hypoxylon adumbratio*: close anastomosed.
8. *Hypoxylon albocinctum*: loose.
9. *Hypoxylon sassafras*: slightly rosy.
10. *Hypoxylon corticium*: conidiophore on subiculum developed experimentally.
- 11—19. Conidiophores and conidia: *Nodulisporium* types I and II.
11. *Hypoxylon albocinctum*: Type I.
12. *Hypoxylon pynerthii*: Type I.
13. *Hypoxylon adumbratio*: *Nodulisporium* type IIa, strongly monopodial.
14. *Hypoxylon entoleucum*: Type I.
15. *Hypoxylon discolor*: Type I.
16. *Hypoxylon sassafras*: *Nodulisporium*, intermediate between types I and II.
17. *Hypoxylon smilacicum*: Type II.
18. *Hypoxylon cuneosporum*: Type II.
19. *Hypoxylon quadratum*: Type II.

wide. Peripheral hyphae compact. Conidia white, very sparse, and restricted to the zones so that they are practically indistinguishable from the surrounding mycelium. Stain and carbonization nil. Growth at 25°C slow, 1.90 mm./day. Cultures on maize and Czapek are less luxuriant than on malt.

*Microscopic Characters:*

Primary mycelium not diagnostic; marginal hyphae rather narrow with a maximum diameter of  $1.7\mu$ . Secondary mycelium nil.

*Conidiophores and conidia* (Fig. II: 17):

The conidiophores are very short, branched dichotomously to the first or second degree at the distal end, easily distinct from the vegetative mycelium by their determinate growth and slightly wider diameter,  $60-220 \times 2.5\mu$ ; each usually bifurcate, producing 2 ultimate fertile branches  $21-30 \times 1.7-2.3\mu$  bearing very shortly spicate or capitate clusters of conidia. Interesting peculiarities are the irregularly swollen axes of the conidiophores, and the broad V-shape of dichotomous branching. The conidia are sessile, relatively small, oval to subglobose, often wide truncate bases, white,  $1.1-1.7 \times 1.7-5.2\mu$ , ave.  $1.5 \times 2.1\mu$ .

9. *Hypoxyton sassafras* (Schw. ex Fr.) Curt.

Berkeley, M. I. *Grevillea* **4**, 52, (1875), Cooke, M. C. *Ann. N.Y. Acad.* **1**, 184, (1878), Currey, F. *Trans. Linn. Soc. Lond.* **22**, 267, (1859), Curtis, M. A. *Geol. & Nat. Hist. Survey of North Carolina* **III**, 140, (1867), Ellis, J. B. & B. M. Everhart *Jour. Mycol.* **4**, 70, (1887), Ellis, J. B. & B. M. Everhart *N. Amer. Pyren.* 641, (1892), Miller, J. H. *World Species of Hypoxyton* **21**, (1961), Owens, C. E. *Proc. Indiana Acad. Sci.* **1911**, 307, (1912), Penzig, O. & P. A. Saccardo *Malpighia* **11**, 493, (1897), Rehm, H. *Hedwigia* **21**, 138, (1882), Shear, C. L. *Mycologia* **20**, 86, (1928), Sydow, H. & F. Petrak *Ann. Mycol.* **20**, 184, (1922),

sub *Hypoxyton bifrons* Ces. & DN. De Notaris, G. *Hedwigia* **2**, 171, (1863), De Notaris, G. *Sphaeriacei Italici* **18**, (1863), Saccardo, P. A. *Fungi Ital.* 579, (1877-1886), Traverso, J. B. *Flora Ital. Crypt.* **1**, 45, (1906).

sub *Hypoxyton callostroma* (Schw.) Berk. Berkeley, M. J. *Grevillea* **4**, 51, (1875), Ellis, J. B. & B. M. Everhart *Jour. Mycol.* **4**, 69, (1887), Ellis, J. B. & B. M. Everhart *N. Amer. Pyren.* 643, (1892).

sub *Sphaeria callostroma* Schw. Schweinitz, L. v.d. *Jour. Acad. Nat. Sci. Philad.* **5**, 15, (1825), Schweinitz, L. v.d. *Trans. Amer. Phil. Soc. Philad. N.S.* **4**, 192, (1832).

sub *Sphaeria sassafras* Schw. Fries, E. M. *Systema Mycologicum* **II**, 343, (1823), Schweinitz, L. v.d. *Syng. Fun. Carolinae* **Sup. 36**, (1822).

Stromata erumpent though decorticated wood or bark, aplanopulvinate,  $1.2-8 \times 2.0-2.6 \times 1.2-2.5$  mm. (Plate II: 7). Surface of stromata often



depressed by shallow concavities. Outer entostroma thin, dark and carbonous, inner basal tissue predominant, corky to somewhat fleshy, brilliant yellow orange. Perithecia 1 to several per stroma, large,  $500-1300 \times 700-1300 \mu$ , occupying the major part of the stroma; ostioles punctate, indistinct. Asci cylindric, long stipitate,  $170-240 \times 3-6 \mu$ , stipes  $80-130 \mu$  long. Spores cylindrical elliptic, equilateral, ends broadly rounded, pale brown,  $3.0-5.5 \times 10.5-14.0 \mu$ , ave.  $3.9 \times 10.2 \mu$ .

*South African Hosts:* *Curtisea faginea*, decorticated wood. In North America this species shows strong preference for *Umbellularia californica*.

*Material examined:* A large quantity of material in the AA, NFC and NYBG herbaria. Martin 390; Nature's Valley, Knysna District, Western Cape, (1958). Martin 661; Yosemite, California, U.S.A., (1961). Martin 773, 774; O'Brien, California, U.S.A., (1961). Martin 1602, 1626; Rockland Co., NY State, U.S.A., (1963).

*Cultural Characters:* (Plate IV: 10):

Germination pattern free spreading. Colonies appressed canescent to sparsely felty, white to pale grey, sometimes with a brownish tinge, subhyaline to opaque; divided during early stages of growth into a submersed marginal zone up to 5 mm. wide and a centre with distinct aerial growth, later becoming zonate with up to 5 zones each 2 mm. wide and about 5 mm. apart. Margin entire, compact, 2—3.5 mm. wide. Conidia appear only with extreme age, between 4 and 8 weeks after inoculation, in small pulvinate masses over the centre of the colony, and are dark nondescript brownish in colour. Stain none. Growth at 25°C very slow, 0.95 mm./day.

*Microscopic Characters:*

Primary mycelium not diagnostic; maximum diameter of the marginal hyphae— $2.1 \mu$ . Secondary mycelium very sparse in quantity, developing in small areas under the white primary mycelium, and is characteristically loosely organised, or slightly ropy, indefinitely branched dichotomously with few anastomoses;  $1.3-3.8 \mu$  diam. (Fig. II: 9).

*Conidiophores and conidia* (Fig. II: 16):

The conidiophores are somewhat difficult to distinguish from the vegetative mycelium except for their pale amber colour and closer branching; each forms an indefinitely dichotomously branched unit  $150-300 \times 3.1 \mu$  with ultimate fertile branches  $17-81 \times 1.2-2.4 \mu$ , sparingly septate. The conidia are borne ubiquitously in small sessile fascicles of 2—3 or singly, on geniculate prominences or from the smooth wall of the sides and ends of the fertile branches. The

conidia are oval to subglobose with narrow truncate bases, pale ochre brown collectively,  $1.7-2.9 \times 1.7-3.7 \mu$ , ave.  $2.2 \times 3.0 \mu$ .

10. *Hypoxylon discolor* Berk. & Br.

Berkeley, M. J. & C. E. Broome Jour. Linn. Soc. **14**, 123, (1875), Petch, T. Ann. Roy. Bot. Gard. Perad. **8**, 155, (1924).

sub *Penzigia discolor* (B. & Br.) Mill. Miller, J. H. Bothalia **4**, 261, (1942).

Stromata pulvinate, usually densely aggregated,  $0.7-4.4 \times 0.7-8.0 \times 0.6-0.8$  mm., sessile or attached to the substrate at a central point only, superficial on wood or decorticated wood and bark (Plate II: 8). Ectostroma at first scabrous and corky, dirty white, later grey and merging with the carbonous entostroma; basal tissue of the entostroma predominant, white or sulphur yellow (Fig. 1: 1). Perithecia few per stroma, relatively large, occupying most of the stromal interior,  $400-600 \times 400-500 \mu$ ; ostioles distinctly papillate. Asci not seen. Spores broadly oval, dark brown  $4.5-8.5 \times 9.0-13.5 \mu$ , ave.  $6.6 \times 11.2 \mu$ .

*South African hosts* unidentifiable, but obviously comprising a great range.  
*Material examined:*

sub *Hypoxylon discolor*. ex Herb. Massee 310, Ceylon (pre-1905), (NYBG).

sub *Penzigia discolor* ex Pretoria Herb. 31062, 32149, (Pret.). Martin 365, 380, 454, 512; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959).

*Cultural Characters* (Plate IV: 12):

Germination pattern free spreading. Colonies velvet fleecy, gleaming white, opaque to subhyaline, very dense, forming a closely knit mat up to 2 mm. high with a coarse surface. A characteristic ruff of mycelium is formed encircling the centre of the colony and 5 cm. away from it; growth otherwise ranges from uniform to zonate with 1-3 zones developed irregularly surrounding the centre. Margin submersed to canescent, entire, with compact peripheral hyphae up to 4 mm. wide. Conidia appear late, in bottle culture 9 months after inoculation, and are very pale fawn-grey over small areas of the mycelium. Stain none, carbonization none. Growth at  $25^{\circ}\text{C}$  slow, 1.80 mm./day. Cultures on maize and Czapek are less luxuriant than on malt.

*Microscopic Characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $2.9 \mu$ . Secondary mycelium uniformly dispersed, consisting of long, sparingly branched and loosely anastomosed filaments  $2.7-4.3 \mu$  diameter.

*Conidiophores and conidia* (Fig. II: 15):

Conidiophores are indistinguishable from the vegetative mycelium except for bearing spores and are branched dichotomously to the first degree over the length of the primary axes, and measure  $300\text{--}500 \times 2.9\mu$ . Conidia arise off the flat surface of the hyphae and not off geniculate protuberances. The fertile branches are  $25\text{--}115\mu \times 1.2\text{--}2.6\mu$ , sparingly septate; conidia acropleurogenous, sessile, borne singly or in groups of 4–9 along their entire length, oval to subglobose, pale fawn-grey collectively,  $2.3\text{--}3.7 \times 2.9\text{--}4.8\mu$ , ave.  $2.8 \times 3.7\mu$ .

11. *Hypoxylon cadigensis* Yates.

Yates, H. S. Philipp. Journ. Sci. **12**, 378, (1917).

Stromata pulvinate, small,  $0.8\text{--}1.6 \times 1.0\text{--}2.2 \times 0.9\text{--}1.1$  mm., attached to the substrate at a central point only, superficial on bark. Ectostroma scabrous in the form of polygonal crusts, corky and dull brown, basal tissue of the entostroma very conspicuous, pure white. Perithecia few per stroma, either vaguely evident or immersed,  $500\text{--}600 \times 600\text{--}700\mu$ ; ostioles medium papillate. Asci cylindric with conspicuously thick walls,  $135\text{--}150 \times 10\text{--}16\mu$ , stalks  $37\text{--}42\mu$ . Spores oval, inequilateral with one side straight or convex, opaque black, with very conspicuous gelatinous sheaths and spiral germ slits,  $8.5\text{--}10.5 \times 17.0\text{--}20.0\mu$ , ave.  $9.6 \times 18.2\mu$ .

*South African Hosts*: unidentified bark.

*Material examined*: Martin 1039; Nature's Valley, Knysna District, Western Cape, South Africa, (1962). Rogers 1616; Jaluit Atoll, Marshall Islands, (1946), (NYBG).

This species did not germinate successfully so that no cultural information is available.

12. *Hypoxylon entoleucum*. Martin nov. sp.

Stromata aplanate crustose, consisting of a thin corky matrix with a carbonous veneer,  $10\text{--}23 \times 41 \times 0.5\text{--}0.6$  mm. (Plate I:4). The perithecia are aggregated but not coalesced, and are clearly evident in outline on the surface of the stroma. Ectostroma evanescent; outer layer of entostroma carbonaceous and also tending to disintegrate with age; basal tissue well developed, pure white. The stroma, although closely appressed to the host bark is actually in connection with it at only a few places where the dark secondary mycelium below the entostroma enters for a short distance. Perithecia globose,  $400\text{--}650 \times 400\text{--}500\mu$ , often broader than deep; ostioles indistinctly papillate. Asci not seen. Spores elliptic navicular with rounded or bluntly pointed ends, light brown,  $5.0\text{--}8.5 \times 14.0\text{--}19.0\mu$ , ave.  $6.4 \times 16.4\mu$ .

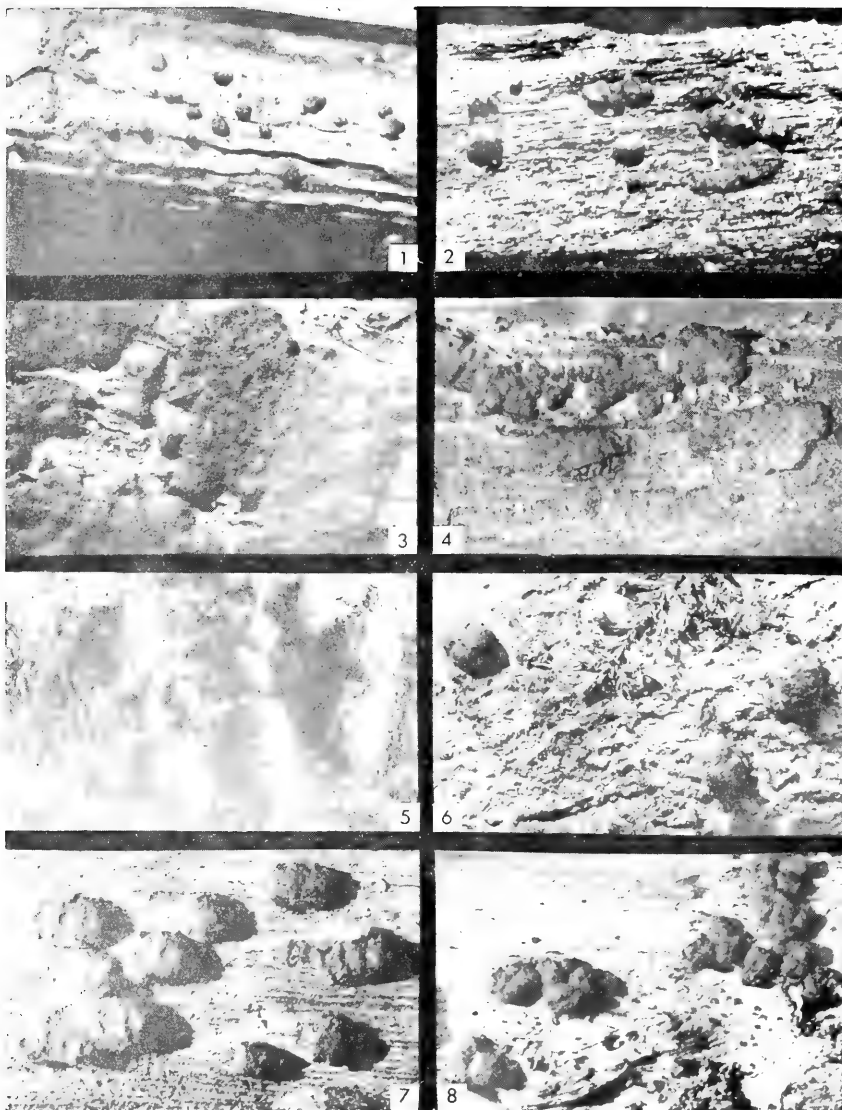


PLATE II. Stromata contd.  
 $1 \times 2.3$ ,  $2-8 \times 3.5$

- 1, 2. *Hypoxylon smilacicum*.
3. *Hypoxylon albocinctum*.
4. *Hypoxylon pyraerthii*.
5. *Hypoxylon cuneosporum*.
6. *Hypoxylon quadratum*.
7. *Hypoxylon sassafras*.
8. *Hypoxylon discolor*.

*South African Hosts:* *Cassine croceum*, bark.

*Material examined:* Martin 362; Nature's Valley, Knysna District, Western Cape, South Africa, (1958).

*Cultural Characters* (Plate III: 9):

Germination pattern free spreading (Fig. II: 2b). Colonies velvet silky to thin felty with a coarse surface, dull white to pale grey, with flat fawn coloured irregular conidial areas 3 mm. high developed in bottle culture. An abundance of coal black bodies produced by the mycelium may become conspicuous with age. Margin entire or cast into small segments, submersed to canescent, compact. No stain or carbonization. Colonies on maize and Czapek are more effuse than on malt and Leonian's agar.

*Microscopic Characters:*

Maximum diameter of the marginal hyphae =  $1.7\mu$  (Fig. II: 3). Secondary mycelium absent. The feature which distinguishes this species from all others investigated except *H. truncatum* is the production of coal black carbonous bodies over most of the surface of the mycelium (Fig. II: 1). Small aggregations of hyphae develop just behind the colony margin. These develop later into white pseudoparenchymatous spheres about  $30\mu$  diameter. About 24—36 hours after initiation these spheres expand, losing all evidence of cellular structure and many of the hyphal contacts with surrounding mycelium. The remaining hyphae swell up to about  $6\mu$  in diameter, turn amber, and may develop wall pitting. The colour of the sphere changes to pale brown and then, as carbonization takes place, to jet black. The fully formed spheres are evident after  $2-2\frac{1}{2}$  days, range from  $100-130\mu$  in diameter, and have a rigid exterior enclosing a centre that is hollow or filled with loose cells.

*Conidiophores and conidia* (Fig. II: 14).

The conidiophores are similar to those of *H. discolor* in that they cannot be distinguished from the vegetative mycelium. They form an indefinite dichotomously branched system  $200-300\mu$  long; with ultimate fertile branches  $130-230\mu$  long, sparingly septate and bearing sessile conidia in small fascicles of 5—8 along their length and singly on geniculate prominences near their ends. Conidia oval, fawn-grey collectively,  $1.7-2.9 \times 3.1-4.6\mu$ , average  $1.9 \times 3.7\mu$ .

### 13. *Hypoxylon minutissimum* Martin, nov. sp.

Stromata minute, globose, uniperitheciate, but gregarious on the surface of decorticated wood, and dull black in colour (Plate I: 5). Perithecia  $200-300\mu$  (wide)  $\times$   $150-250\mu$  (high) ostioles papillate, indistinct. Asci clavate, short

stipitate,  $75-90 \times 8\mu$ , stipes  $18-21 \times 3\mu$ . Spores oval to subglobose, light brown,  $5.0-8.0 \times 6.0-10.5\mu$ , ave.  $6.2 \times 8.5\mu$ .

*Material examined*: Martin 269; on decorticated wood of *Acacia karoo*, near Alexandria, Eastern Cape, South Africa, (1958).

*Cultural Characters* (Plate IV: 1, 3):

Germination pattern radiate. Colonies velvet felty, uniformly dense, with very fine smooth surface. Aerial mycelium gleaming white, up to 3.5 mm. high near the centre and thinning gradually towards the margin and consequently turning from opaque to subhyaline. The margin is usually distinct as a zone 3 mm. broad, canescent, white, subhyaline and entire. Marginal hyphae are compact and run closely parallel. Conidia none. Stain and carbonization none. Growth at  $25^{\circ}\text{C}$  slow, 2.06 mm./day. Cultures on maize and Czapek are less luxuriant at first than on malt. Czapek bottle cultures develop deep surface wrinkling and exude olivaceous droplets with age while olive yellow stain develops on the reverse. Leonian's bottle cultures develop carbonization but no stain.

*Microscopic Characters*:

Primary mycelium undistinguished, marginal hyphae with a maximum width of  $1.4\mu$ ; secondary mycelium nil.

**14. *Hyposylon mastoideum* (Fr.) Martin comb. nov.**

sub *Psilosphaeria mammoidea* Cooke: Cooke, M. C. Grevillea **8**, 67, (1897).

sub *Rosellinia mammoidea* (Cke) Sacc. Massee, G. Kew Bull. **1898**, 129, (1898), Saccardo, P. A. Syll. Fung. **1**, 263, (1882).

sub *Rosellinia mastoidea* (Fr.) Sacc. Bresadola, G. & Saccardo, P. A. Malphighia **11**, 284, (1897), Saccardo, P. A. Syll. Fung. **1**, 258, (1882), Traverso, J. B. Flor. Ital. Crypt. **1**, 459, (1906).

sub *Sphaeria mastoidea* Fr.: Berkeley, M. J. Mag. Zool. & Bot. **6**, 362, (1841), Cooke, M. C. Handbook of British Fungi **11**, 868, (1871), Durieu de Maisonneuve & Montagne, J. F. C. Explor. Alger. **1**, 504, (1846), Fries, E. M. Syn. Scler. Suec. **39**, (1823).

Stromata very variable, uniperitheciate, biperitheciate or with several perithecia aggregated under the same stromal covering in ranging degrees of proximity;  $0.5-4 \times 0.5-10 \times 0.8-1.6$  mm.; colour usually shiny black (Plate I: 1). The similarity of uniperitheciate stromata to the perithecial units of aggregate stromata makes it hard to recognise more than one species although many authors have obviously done so. Outer entostroma hard black and carbonous, merging gradually into the basal tissue which is brown and uncarbonized. Perithecia globose or semicircular due to broadening of the bases,  $400-1400 \times 700-1500\mu$ ; ostioles papillate and usually distinct. Asci clavate,

100—130 × 11  $\mu$ ; stipes variable but usually short, 21—65 × 3  $\mu$ . Spores equilateral, oval-elliptic with rounded ends, dark brown, 5.0—10.5 × 10.0—22.0  $\mu$ , ave. 7.6 × 14.5  $\mu$ . There is probably a very wide host range; unfortunately much of the substrate could not be identified with certainty. The following South African hosts are definitely known: *Olea capensis*, *Cassine croceum*, *Gonioma kamassi*, *Sideroxylon inerme*.

*Material examined:*

- sub *Hypoxylon mastoideum*. Martin 9, 11, 20, 27, 36, 42, 47, 81, 94, 233, 347, 348, 431, 433, 460, 466; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959). Martin 414; Alexandria Forest, Albany District, Eastern Cape, South Africa, (1958). Martin 531; Highlands, Albany District, Eastern Cape, South Africa, (1959). Martin 986, 1527; San Blàs, Nayarit, Mexico, (1961, 1962). Martin 1126, 1175; Lake Ozark, Missouri, U.S.A., (1962).
- sub *Hypoxylon semi-immersum*. Blackwell; in Herb. IMI. 53, 998; Mulgrave Woods, Yorks., England, (1953), (CMI).
- sub *Rosellinia mammoidea*. Parks; in Herb. NFC. 22488, (1929), (NFC).
- sub *Rosellinia mastoidea*. Kopf & Rogers; in Herb. Rogers 3145, on *Aleurites moluccana*, Mannali Gulch, Lauai, Hawaii, (1947), (NYBG). D. Saccardo; Mycotheca italica 1476 on *Salvia officinalis*, Rome, (1904), (NYBG).

*Cultural Characters* (Plate IV: 2, 4, 5):

Germination pattern radiate (Fig. II: 2a). Colonies fleecy to velvet lanose, gleaming white, changing little with age or becoming tinted light yellow-brown, uniform or zonate with up to 3 zones, each 2 mm. wide and 5 mm. apart after 7 days, growth. The degree of luxuriance varies with the strains; the hyphae, always densely packed, range from 3 to 15 mm. in height. With age some strains produce marginal plumes of hyphae that serve as a distinguishing characteristic. Margin variable in character, either not clearly distinct, appressed and rising abruptly into the rest of the colony, or up to 3 mm. broad, submersed, colourless, lobed or entire, and compact. Conidia infrequently produced, usually with age, after 3 weeks (plate culture) or 10 months (bottle culture); pale fawn-grey. Stain and carbonization none. Growth at 25°C very slow, 0.92—1.13 mm./day. Cultures on maize are less luxuriant, and those on Czapek grow poorly, almost completely submersed initially.

*Microscopic Characters:*

Primary mycelium undistinguished, marginal hyphae with maximum width of 2.0  $\mu$ . Secondary mycelium nil.

*Conidiophores and conidia:*

Conidiophores belong to both types of *Nodulisporium* type II previously described (Martin 1967). The conidiophores are branched to the second degree over most or all of the primary axes. In Type IIa the branching is dichotomous, and the system ranges from 200—300 in length while the ultimate fertile branches are  $30-80 \times 1.2-1.8\mu$ . In Type IIb the conidiophores are more clearly recognizable as units ranging from  $150-250\mu$  in length, and the ultimate fertile branches are  $37-75\mu \times 1.2-1.8\mu$ . The branching is characteristically ternate, and the fertile portion of the ultimate branches is characteristically geniculate.

Conidia in all cases are sessile, produced in short spicate apical clusters without apparent order, and are oval to subglobose, wide based, with rounded ends pale fawn-grey collectively,  $1.4-2.3 \times 2.0-4.0\mu$ , ave.  $1.8 \times 2.7\mu$ .

15. *Hypoxylon albocinctum* E. & E.

Ellis, J. B. & B. M. Everhart Proc. Nat. Acad. Sci. Philad. III 20, 229, (1890), Miller, J. H. World Species of *Hypoxylon* 77, (1961). Shear, C. L. Lloydia 8, 248, (1945).

sub *Hypoxylon hydnicolum* (Schw.) Sacc. Ellis, J. B. & B. M. Everhart North Amer. Pyren. 657, (1892), Saccardo, P. A. Syll. Fung. 1, 383, 1882.

Stromata aplanopulvinate to effuse,  $2.2-19 \times 3.0-53 \times 0.5-1.8$  mms., sometimes with a rather indistinct outline; surface flat or nearly so, in contrast to *H. serpens*, since the perithecia do not appear above the stromal surface (Plate II: 3). Colour dull or shiny black. Ectostroma and entostroma similar to that in *H. serpens*. Perithecia normally densely clustered in the stroma and sometimes flattened laterally by mutual pressure, ovoid to conic,  $200-800 \times 400-1000\mu$ ; ostioles papillate or indistinct, not as conspicuous as in *H. serpens*. Asci cylindric, or slightly clavate, very variable in total length depending on the extent of the stipes,  $65-180 \times 5-11\mu$ ; stipes  $20-100 \times 3\mu$ . Spores oval, equilateral, light or dark brown, the latter usually opaque,  $3.0-7.5 \times 6.5-15.0\mu$ , ave.  $5.8 \times 11.9\mu$ .

There is a very wide range of hosts. Known South African hosts are: *Olea capensis*, *Cassine crocea*, *Vepris lanceolata*.

*Material examined:* A large number of species in the CMI, Rijks and New York Herbaria. Morgan 884; on *Crataegus*, Preston, Hamilton Co., Ohio, U.S.A., (1890), (NYBG). Martin 129, 153, 397, 581, 582; Fernkloof, Grahamstown, E. Cape, South Africa, (1959, 1960). Martin 150, 309, 324, 335, 336, 338, 368, 375, 403, 517, 576, 578, 1019; Nature's Valley, Knysna District, Western Cape, South Africa, (1958—1962). Martin 577; Wilderness, Knysna District, Western Cape, South Africa, (1959). Martin 586; Alexandria Forest, Eastern Cape, South Africa, (1960). Martin 614; Los Angeles,



California, U.S.A., (1961). Martin 899; ex C. Booth. CMI, Surrey, England, (1961). Martin 909, 934; Mazatlán, Sinaloa, Mexico, (1961). Martin 970, 980, 988, 989, 992, 1573; San Blàs, Nayarit, Mexico, (1961, 1962). Martin 1168; Lake Ozark, Missouri, U.S.A. (1962). Martin 1604, 1616, 1617, 1622; Rockland Co., N.Y., U.S.A., (1963).

*Cultural Characters* (Plate IV: 8, 11):

Germination pattern free spreading. Colonies at first velvety (1—5 days) later becoming velvet lanose with various degrees of luxuriance. The aerial mycelium forms a dense opaque white mat up to 4 mm. high with a fine smooth surface and normally with a pronounced "pile". Growth ranges from completely uniform to strongly zonate; in the latter case 4—6 zones each 2 mm. wide and 4—10 mm. apart were formed in 2 weeks. The zones are clearly formed by the repeated unequal development of the peripheral hyphae, some of which grow faster than the others and increase the diameter of the colony, while the remainder form a ruff on the surface of the colony. While the new zone is consolidated by ramification of the original pioneer hyphae, fresh hyphae grow out to form the next zone. The surface of the colony varies from strictly even to irregular and cushiony in aspect. The margin is entire or evenly segmented and may be distinct from the interior of the colony as a canescent or submersed zone 4—15 mm. broad, but is more commonly formed of dense aerial appressed hyphae that rapidly merge into the velvet growth behind. The marginal hyphae are extremely compact. Conidia are infrequently produced, after about 3 weeks in plate culture and between 1 and 8 months in bottle culture. They are white or light fawn in colour, and cover most of the surface of the colony, though not nearly as extensively as in *H. serpens*. Stain nil; "carbonization" of the substrate occurs in bottle culture but not in plate culture, after 2 months, to a variable extent, forming a dark crust 2 mm. deep beneath the aerial mycelium. Growth at 25°C very slow to moderate, 1·20—3·03 mm./day. Cultures on all media are broadly similar, but growth is less luxuriant on Czapek.

*Microscopic Characters:*

The primary mycelium is distinguished from all other species in that the septae in the marginal hyphae are usually accompanied by a conic or globose swelling in the mycelium just below (Fig. II: 4). This feature appears to be constant for the majority of the strains studied. The maximum diameter of the hyphae of the marginal hyphae is 2·2 $\mu$ .

The secondary mycelium consists of long stout darkly coloured hyphae 1·4—10·6 $\mu$  diam. which are loosely interlocked to closely anastomosed (Fig. II: 8). They appear when the colony is older than 5 days, and run under the surface of the primary mycelium.

*Conidiophores and conidia* (Fig. II: 11):

These comprise an indefinitely branched system whose units measure  $150\text{--}650\mu \times 1.5\text{--}3\mu$ . The conidiophores are not really distinct from the vegetative mycelium. Each unit consists of a main axis, sometimes weakly differentiated, which is divided dichotomously to the second degree over at least half of its axis. The ultimate fertile branches are  $4.5\text{--}155 \times 1.7\text{--}2.5\mu$ , and are normally 1—3 septate, and smooth or irregular in outline. The conidia are usually scattered down their length but may be in groups of 2 or 3. There is no recognizable fertile region on the ultimate hyphae and the conidia apparently develop at random. The conidia are sessile, oval to subglobose, equilateral and rounded at both ends or sometimes bluntly pointed distally or with truncate bases, hyaline and colourless individually but collectively white, fawn coloured or very pale grey;  $1.8\text{--}3.4 \times 2.9\text{--}6.9\mu$ , ave.  $2.7 \times 4.5\mu$ .

16. *Hypoxylon pyraerthii* Bres.

Bresadola, G. Ann. Mycol. 9, 275, (1911), Miller, J. H. World Species of *Hypoxylon*, 82, (1961).

Stromata usually indefinitely effused but sometimes aplanopulvinate,  $1.5\text{--}16 \times 2.3\text{--}35 \times 0.5\text{--}0.8$  mm.; always partly embedded in the substrate though not necessarily erumpent through bark; surface characteristically dull brown to black and coarsely grained and often granulate or warty, never shiny (Plate II: 4). Entostroma mostly carbonous, forming bands between the perithecia; basal tissue slight in quantity. Perithecia variable in shape depending on their distance apart, ovoid or conic due to mutual pressure,  $200\text{--}400 \times 400\text{--}600\mu$ ; ostioles indistinct papillate and not raised above the stromal level. Asci clavate or cylindric,  $130\text{--}180 \times 8\text{--}11\mu$ , stipes  $51\text{--}85\mu$ . Spores broadly oval, equilateral with ends blunt pointed, in varying shades of brown,  $5.0\text{--}9.0 \times 13.5\text{--}19.0\mu$ , ave.  $6.7 \times 15.5\mu$ .

Hosts: *Olea capensis* and wood unidentified.

*Material examined*: Martin 46; Nature's Valley, Knysna District, Western Cape, South Africa, (1958). Martin 218; Hogsback nr. Alice, Eastern Cape, South Africa, (1958).

*Cultural Characters* (Plate IV: 7):

Germination pattern free spreading. Colonies velvet felty, similar to *H. albocinctum* but less luxuriant and more closely appressed uniformly opaque white. Margin not clearly distinct, canescent to velvety, entire, with compact peripheral hyphae. Conidia produced after 8 months in bottle culture but not on plates, pale fawn-grey in colour. Stain nil. Carbonization of the mycelium occurs to a variable extent, starting at and extending from the centre of the colony outwards. Growth at  $25^{\circ}\text{C}$  moderate, 3.2 mm./day. Czapek bottle

cultures, though less luxuriant at first, eventually guttate golden brown droplets and develop stain of the same colour.

*Microscopic Characters:*

These are very similar to those of *H. albocinctum*.

Marginal hyphae have a maximum diameter of  $2.0\mu$ . The secondary mycelium is densely branched and closely anastomosed,  $1.4-3.0\mu$  in diameter.

*Conidiophores and conidia* (Fig. II: 12).

These are also of the same general type as *H. albocinctum*, but may be distinguished by the tendency of the conidia to arise in groups of 2 or 3 as well as singly, and by their larger average size. The conidiophores measure  $400-500\mu \times 3-4\mu$  branched dichotomously to the second degree over the length of the primary axis. The fertile branches are  $88-106 \times 1.9-3.0\mu$ , irregular in outline. The conidia are sessile, elliptic, equilateral with bluntly pointed or rounded ends, wide based, grey or fawn collectively  $1.7-3.4 \times 4.0-7.4\mu$ , ave.  $2.8 \times 5.2\mu$ .

**17. *Hypoxylon adumbratio* Martin nov. sp.**

Stromata usually multiperitheciate and aplanate-effuse, but sometimes pulvinate when containing one or a few perithecia,  $4.2-96 \times 6.0-153 \times 0.9-2.5$  mm. (Plate I: 8). Surface of the stroma shiny black, and smooth or uneven depending on the degree of immersion of the perithecia within. Perithecia relatively large,  $750-1200 \times 700-2000\mu$ , ostioles papillate, usually tapering and spout shaped, often encircled superficially by one or more ridges in the stromal surface that resemble the truncate discs of those species in the section *Annulata* (*H. stygium*, *H. truncatum* etc.). Asci cylindric, long stipitate,  $180-250 \times 5.7\mu$ , stipes  $100-170\mu$ . Spores oval, inequilateral, navicular with one side straight and the other concave; dark chocolate brown;  $3.5-7.0 \times 11.0-16.0\mu$ , ave.  $5.3 \times 13.1\mu$ .

*Host: Olea capensis.*

*Material examined:* Martin 91, 154, 288, 393, 451, 465, 496, 554; Nature's Valley, Knysna District, Western Cape, South Africa, (1959, 1958).

*Cultural Characters* (Plate IV: 6):

Germination pattern free spreading. Colonies velvet lanose, with aerial mycelium 2-3 mm. high, gleaming opaque white and smooth, growth normally uniform except in some cases where a "halo" effect arises due to the rise in height of the mycelium from the centre towards the margin. Margin indistinct, or forming a zone 3-5 mm. broad, submersed to canescent, or forming a ruff of velvet silky hyphae, entire or very slightly segmented; peripheral hyphae

compact and lying parallel. Conidia developing late, and never profusely, fawn brown in colour. Stain variable, absent in plate culture, but developing in bottle cultures after 14—18 days, light brown, chocolate, or light purple; diffuse throughout the colony. Bottle cultures 8 months old also developed carbonization of the medium as a black layer 0.3 mm. deep. Growth at 25°C very slow, 1.49 mm./day. Cultures on maize and Czapek are less luxuriant than on malt.

*Microscopic Characters:*

Primary mycelium not diagnostic; maximum diameter of marginal hyphae =  $2.2\mu$ . Secondary mycelium crustose, composed of very short densely branched and closely anastomosed hyphae,  $1.7\text{--}4.2\mu$  diam. (Fig. II: 7).

*Conidiophores and conidia* (Fig. II: 13):

These comprise an indefinitely dichotomously branched system  $500\text{--}1000\mu$  long, whose ultimate fertile branches bear small clusters of sessile pleurocrogenous conidia. This is a good example of *Nodulisporium* type IIa as defined previously (Martin, 1967).

The main axes, about  $2.5\mu$  in diameter, are strongly monopodial and clearly distinct, since they bear relatively short lateral fertile branches off the distal segments. The fertile branches are  $11\text{--}57 \times 2.0\text{--}2.7\mu$ , and are regularly geniculate towards the apices. The conidia are acropleurogenous, elongate elliptic or pyriform, normally with the distal end acute and the other rounded,  $2.0\text{--}3.4 \times 5.1\text{--}12.5\mu$  ave.  $2.7 \times 7.4\mu$ . The elongate shape of the conidia is unusual, only being matched by that of *H. mammatum*.

*Foreign Species with Imperfect Stages.*

18. *Hypoxylon aquilum* (Fr.) Martin comb. nov.

Berlése, A. N. & G. Bresadola Ann. Sco. Alp. **14**, 18, (1887—1888), Bizzozero, G. Flora Ven. critt. **I**, 191, (1885), Brooks, F. T. Plant Diseases, 198, (1953), Dennis, R. W. G. British Cup Fungi, 181, (1960), De Notaris, G. Giorn. Bot. Ital. **1**, 322—325, (1844), De Notaris, G. Sferiacei Italici **21**, (1863), Ellis, J. B. & B. M. Everhart N. Amer. Pyren. **163**, (1892), Fabré, J. H. Ann. Sci. Nat. **VI**, **9**, 78, (1879), Fuckel, L. Symbolae Mycologicae **148**, (1869—1870), Hennings, P. Bot. Ver. Prov. Brand. **40**, 155, (1898), Lambotte, E. Flora myc. belge **II**, 292, (1880), Miller, J. H. Mycologia **20**, 191, (1928), Miller, J. H. Bothalia **IV**, 257, (1942), Rabenhorst, G. L. Kryptflor. Deutsch Krypt. Flor. **I**, 187, (1844—1848), Rabenhorst, G. L. Kryptflor. Deutsch **II**, 224, (1887), Rehm, H. Berichte Natur. ver Augs. **26**, 129, (1881), Rehm, H. Ascomycetes Lojkani Hungaria, 27, (1882), Rehm, H. Hedwigia **21**, 131, (1882), Rick, J. Broteria ser. science. nat. **1**, 184, (1932), Saccardo, P. A. Fungi Ital. **586**, (1886—1887), Shear, C. L. Mycologia **33**, 324, (1941),

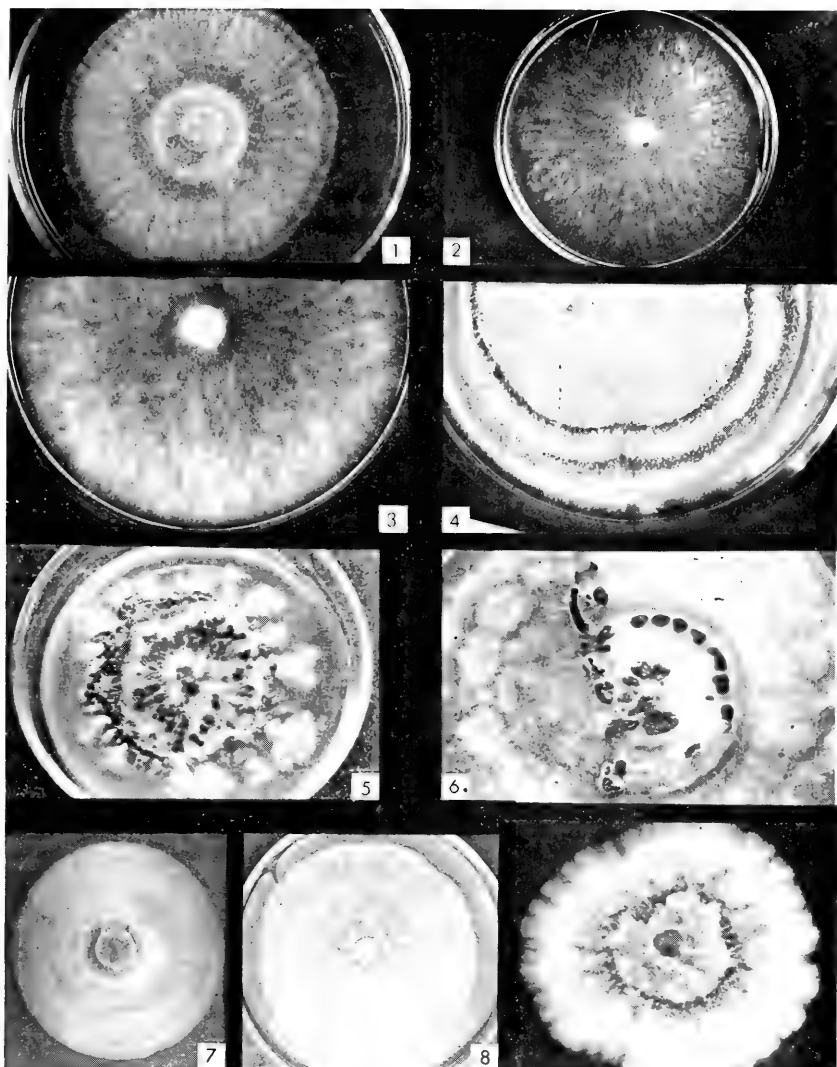


PLATE III. Culture morphology. All on malt agar at 25°C and 14 days old unless otherwise stated.

1. *Hypoxylon perusensis*.
2. *Hypoxylon ravenelii*.
3. *Hypoxylon corticium* (*H. aridicolum* similar).
4. *Hypoxylon serpens*.
5. *Hypoxylon thelenum* (*H. aquilum* and *H. necatrix* similar).
6. *Hypoxylon diathrauston*.
7. *Hypoxylon regale*.
8. *Hypoxylon cuneosporum*.
9. *Hypoxylon entoleucum*, showing black sclerotia near centre.

- Theissen, F. Beih. Bot. Cent. **27**, 393, (1910), Wallroth, K. F. W. in Bluff & Fingerhuth: Comp. Flor. Germ. **II**, 835, (1833), Winter, G. Hedwigia **24**, 100, (1885).
- sub *Rosellinia byssiseda* Tode. Schröter, T. Kryptflora Schles. **299**, (1908), Traverso, J. B. Flor. Ital. Crypt. **1**, 456, (1906).
- sub *Sphaeria aquila* Fries. Berkeley, M. J. in Smith, J. E. English Flora **5**, (2) **259**, (1836), Berkeley, M. J. Mag. Zool. & Bot. **6**, 361, (1841), Cooke, M. C. Ann. NY. Acad. Sci. **1**, 186, (1878), Cooke, M. C. & J. B. Ellis Grevillea **5**, 50, (1876), Fries, E. M. Systema Mycologicum **442**, (1823), Fries, E. M. Syn. Scler. Suecia **37**, (1823), Kickx, J. Flor. crypt. Flandres **329**, (1967).
- Stromata ovoid or globose,  $1.2-1.8 \times 1.2-1.8 \times 1.1-1.9$  mm. normally uniperitheciate, and usually closely aggregated, dull brown to black in colour. Subiculum of dark reticulate hyphae normally present. Outer entostroma hard, black carbonous; basal tissue variable in extent, corky and dull brown at maturity. Perithecia large, oval,  $900-1200 \times 1000-1100\mu$ , ostioles prominent papillate. Asci cylindric, short stipitate,  $160-200 \times 7.11\mu$ ; stipes  $50-120\mu$ ; ascus plugs constricted. Spores elongate, elliptic or navicular, inequilateral with one side flat or gibbous, dark brown, bearing a short obtuse appendage at both ends,  $7.0-100.0 \times 17.5-22.5$ , ave.  $8.1 \times 20.4\mu$ ; germ slit on convex side of the spore. This species is close to *H. corticium*, differing mainly in the appendiculate spores.

*Material examined:* A large quantity of material in the Rijks Herbarium. Martin 1758; ex Carroll, San Cristobal, Chiapas, Mexico (1963). Martin 1797, 1799; ex Carroll, Elsehored & Sterns Klinten, Denmark (1963).

#### *Cultural Characters:*

Germination pattern free spreading. Colonies silky, fine in texture, uniform, dull white; margin not distinct, appressed, entire with peripheral hyphae lying together. Stain absent; carbonization usually present in oval or fleck-shaped areas, giving a characteristic mottled effect, and serving to distinguish the species from *H. corticium*. Growth at 25°C moderate to fast,  $3.30-7.70$  mm./day.

#### *Microscopic Characters:*

Primary mycelium not diagnostic; maximum diameter of the marginal mycelium =  $2.8\mu$ . Secondary mycelium well developed, uniform, ropy or reticulate, dark brown with hyphae  $2.8-4.3\mu$  in diameter.

Imperfect stage (Fig. III: 3):

Brefeld, O. Untersuchungen aus dem gesamtgebiete der Mykologie **X**, Ascomyceten **2**, 258, 1891. Cooke, M. C. Handbook of British Fungi **II**, 853, 1871. Kirschstein, W. Trans. Brit. Mycol. Soc. **18**, 303, 1934. Miller, J. H. Mycologia **20**, 326, 1928. Ramsey, C. B. Proc. Indiana Acad. Sci. **1914**, 254,

- 258, 1914. Saccardo, P. A. Atti. Soc. Ven. Trent. Sci. Nat. **II**, 108, 1873, sub *Sporotrichum fuscum*.

The conidiophores lack pigmentation but are distinguishable from the vegetative mycelium by determinate growth. They measure  $225-570 \times 3-4\mu$ , arise from the upper segments of the primary axes and are dichotomously branched to the second degree. The fertile branches are variable in length,  $8.75 \times 2.5-3.8\mu$  and are slightly swollen or produced into a distinct globose head. The conidia are acropleurogenous, sessile on small geniculate protuberances, not arranged in any definite order, oval to botuliform with wide truncate or narrow or convex bases, greenish-grey collectively,  $2.5-3.1 \times 3.7-6.8\mu$ , ave.  $3.0 \times 5.0\mu$ .

**19. *Hypoxylon thelenum* (Fr.) Martin.**

- sub *Byssosphaeria thelena* (Fr.) Cke. Cooke, M. C. Grevillea **15**, 81, (1887)-sub *Rosellinia thelena* (Fr.) Rab. Bizzozero, G. Flora Ven. critt. **I**, 191 (1885), Bresadola, G. & P. A. Saccardo Malpighia **13**, 437, (1899), Cesati, V. Hedwigia **14**, 14, (1875), Ellis, J. B. Proc. Acad. Nat. Sci. Philad. **III**, 25, 22, (1895), Ellis, J. B. & B. M. Everhart N. Amer. Pyren. 166, (1892), Hennings, P. et al. Ascomycetes, in Krypt. Flora der Mark Brand **VII**, 212, (1905), Karsten, P. A. Mycologia fennica **II**. Pyrenomycetes, 45, (1873), Lambotte, E. Flora myc. belge 293, (1880), Rabenhorst, G. L. Deutsch Kryptflora **I**, 187, 1844, (1848), Rabenhorst, G. L. Kryptflor. Deutsch **II**, 226, (1887), Rick, J. Broteria ser. cienc. nat. **I**, 190, (1932), Saccardo, P. A. Nuovo Giorn. Bot. Ital. **7**, 328, (1875), Saccardo, P. A. Fungi Ital. 587, (1877-1886), Saccardo, P. A. Sylloge Fungorum **I**, 352, (1882), Schröter, T. in Cohn: Kryptflor. von Schlesien 229, (1908), Traverso, J. B. Flor. Ital. Crypt. **I**, 456, (1906).
- sub *Sphaeria thelena* Fr. Cooke, M. C. Handbook of British Fungi **II**, 835, (1871), Fries, E. M. Syn. Scler. Suec. 36, (1823), Kickx, J. Flore crypt. Flandres 329, (1867).

Stromata ovoid, sometimes with conical vertices,  $0.9 \times 3.5 \times 0.9-8$  mm.  $\times 0.8-1.0$ ; usually gregarious and embedded in a subiculum of dense matted hyphae with ropy anastomoses; surface dull murky brown to black, basal tissue slight or vestigial, dull brown. Perithecia one to several per stroma, evident only at vertices or evident to the bases, globose with conical vertices,  $700-1300\mu$ ; ostioles prominent papillate. Asci cylindric, short stipitate,  $220-260 \times 10-11\mu$ , stipes  $60-70\mu$ ; Ascus plugs constricted. Spores inequilateral with one end gibbous or straight, dark brown with long acicular tails on both ends,  $5.0-11.5 \times 15.5-31.0$ , ave.  $8.0 \times 23.9\mu$ . Germ slit on convex side of the spore.

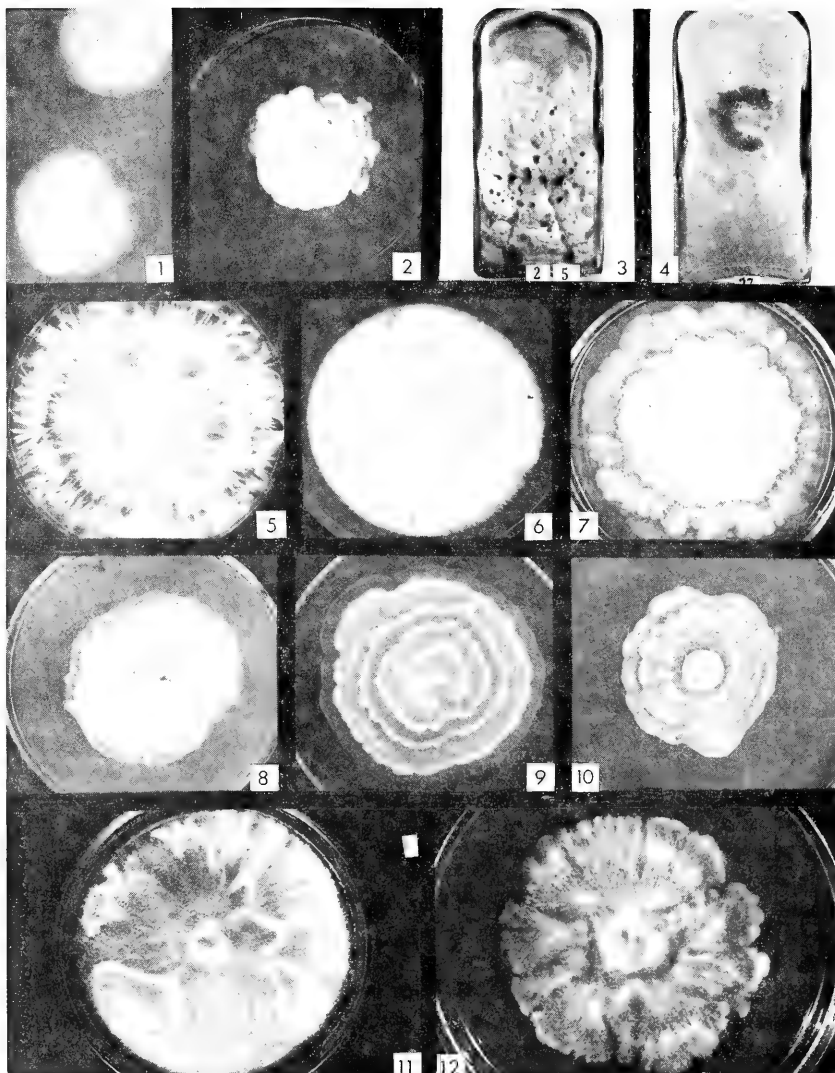


PLATE IV. Culture Morphology contd.

1. *Hypoxylon minutissimum*: Young culture 7 days old on maize, showing fine velvet surface.
2. *Hypoxylon mastoideum*: Young culture 10 days old on malt, showing lanose centre (*H. chrysoconium* similar).
3. *Hypoxylon minutissimum*: Czapek bottle culture 1 month old, showing exudation.
4. *Hypoxylon mastoideum*: Maize bottle culture 1 month old, showing conidial development around inculum.
5. *Hypoxylon mastoideum*: Malt plate culture 1 month old, showing plumose development.
6. *Hypoxylon adumbratio*.
7. *Hypoxylon pyraerthii*.
8. *Hypoxylon albocinctum* on Leonian's agar showing extreme zonation.
9. *Hypoxylon smilacicolum* on Leonian's agar.
10. *Hypoxylon sassafras*.
11. *Hypoxylon albocinctum*; non-zonate strain.
12. *Hypoxylon discolor*.



*Material examined:*

- Bas 1437C; on *Betula*, Bergen, (1958), (R).  
Broome in Rabenhorst's *Fungi europaei* 1536; on *Pinus*, Batheaston, Bath, England (R).  
Desmazières 271; North France, (R).  
Geesteranus 3426; on *Picea*, Baxterl-Best, Veldeisbos, Holland, (1946), (R).  
Jack in Rabenhorst's *Fungi europaei* 757; Salemi, Italy, (R).  
Martin 1798; ex Carroll 453, Hareskov, Copenhagen, (1963).  
Rick; S. Leopoldo, Rio Grande do Sul, Brazil, (1908), (R).  
Saccardo; *Mycotheca italica* 627, on *Abies excelsa*, Padua, Italy, (1900), (R).  
*Mycotheca italica* 1028, on *Abies*, Bosco, Belluno, Italy, (1902), (R).  
Scharvo & Schnall; on *Quercus*, München, Hartmannshofen, Germany, (1891), (R).  
Splitgerber; on *Fagus*, (R).

*Cultural Characters* (Plate III: 5):

Germination pattern free spreading. Colonies canescent, appressed, uniform, dull white; margin segmented but not clearly distinct, with peripheral hyphae lying close together. Stain none; carbonization slight, in fleck formation. Growth at 25°C fast, 4.00 mm./day.

*Microscopic Characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae  $1.8\mu$ . Secondary mycelium loose in construction, uniform,  $4.3\text{--}7.8\mu$  diam. Conidiophores and conidia: None observed.

This species is hard to distinguish from *H. aquilum* in culture.

**20. *Hypoxylon necatrix* (Hartig) Martin comb. nov.**

sub *Rosellinia necatrix* (Hartig) Berl: Brooks, F. T. *Plant Diseases*, 197, (1953), Cooley, J. S. *Bot. Rev.* **12**, 88, (1946), Hartig, R. *Textbook of the diseases of trees*, 82, (1894), Matz, J. *Puerto Rico Dept. Agr. y Trabajo Circ.* **32**, 1—20, (1920), Raabe, R. D. & G. A. *Zentmeyer Calif. Avoc. Soc. Yearbook* **39**, 182—174, (1955), Saccardo, P. A. *Sylloge Fungorum XVII*, 595, (1905), Stevens, F. L. *The Fungi which Cause Plant Disease*, 232, (1919).

Stromata uniperitheciate, glomerular, dull black, 1.5—1.6 mm. in diameter, embedded in dense brown ropy subiculum. Perithecia globose, large 1200—1400 $\mu$  diam.; ostioles papillate but not conspicuous. Asci not seen. Spores elongate elliptic, inequilateral, flat to concave sided, with ends produced:—sometimes acuminate,  $5.7\text{--}8.7 \times 32.0\text{--}47.0\mu$ , ave.  $6.8 \times 38.2\mu$ .

*Material examined:* Martin 895; ex Centraalbureau voor Schimmelcultures, Baarn, Holland, (1961), (Culture only). Thomas; on *Pyrus malus*, Watsonville, California, U.S.A., (1933) (NYBG),

*Cultural Characters:*

Germination pattern free spreading. Colonies silky, growing freely with a fine texture, uniform, pure white. Margin entire, not distinct, with peripheral hyphae widely dispersed. Stain none, carbonization slight, in fleck formation. Growth at 25°C fast, 4.00 mm./day.

*Microscopic Characters:*

Primary mycelium with subseptate bulbous swellings; marginal hyphae with a maximum diameter of  $2.0\mu$ . Secondary mycelium not observed. Imperfect stage (Fig. III: 1):

sub *Dematophora necatrix* (Hart) Berl.

Behrens, J. Centralblatt für Bakteriologie **II**, 3, 584—589, 639—645, 743—750, (1897), Berlèse, A. N. Rivista di Patologia vegetale **1**, 5—17, 33—46, (1892), Hansen, H. N., Thomas H. E. & H. Earl Thomas; Hilgardia **10**, 561—565, (1937), Hartig, R. Untersuch Forstbot. Inst. Münch. **3**, 95—140, (1883), Hartig, R. Textbook of the diseases of trees, 82, (1894), Prillieux, M. Bull. Soc. Mycol. de France **20**, 30—38, (1904), Rant, A. Bull. Jard. Bot. Buitenzorg **2**, 1—22, (1916), Stevens, F. L. Plant Disease Fungi, 163, (1925), Viala, P. Monographie du pourridié des vignes et des arbres fruitiers. Montpellier, (1891).

sub *Graphium necatrix* (Hart.) Trav. Brooks, F. T. Plant Diseases, 197, (1953), Marchionatto, J. B. Rev. Arg. Agron. **3**, 153—158, (1936), Traverso, J. B. Flora Ital. Crypt. **1**, 454, (1906).

Conidiophores are produced on dull brown ropy coremia of the *Graphium* type. Coremia are produced both in association with the stromata and on the colonies with extreme age, project straight outwards, and measure  $800\text{—}1800 \times 18\text{—}56\mu$ . The conidiophores are not distinctly recognizable since their stalks below the fertile region are tightly coiled and are also indistinguishable from the supporting mycelium of the coremium. They are branched dichotomously to the second degree so that the apex of the coremium resembles a small brush; the fertile branches are  $18\text{—}48 \times 2.7\text{—}3.6\mu$  and bear the conidia pleurogenously off geniculate protrusions. The conidia are sessile, elongate elliptic to narrow cylindric, with truncate bases, dull white *en masse*,  $1.8\text{—}2.8 \times 4.7\text{—}8.1\mu$ , ave.  $2.2 \times 5.7\mu$ .

21. *Hypoxyylon diathrauston* Rehm. Miller, J. H. World Species of Hypoxylon, 60, (1961), Rabenhorst, L. Kryptoflora Deutsch **II**, 857, (1887), Rehm, H.

Berichte Naturh., Ver. Augs. **26**, 69, (1881), Rehm, H. *Hedwigia* **21**, 48, (1882).

Stromata globose to pulvinate,  $0.6-4.0 \times 0.6-5.0 \times 0.7-1.2$  mm. forming small irregular patches of indefinite extent. No subiculum. Ectostroma dull brown, persistent up to maturity as a veneer then wearing off to expose the black carbonous entostroma; basal tissue slight, corky, dull white. Perithecia 1-4 per stroma, evident to base or only at the vertices, globose with conic upper halves,  $600-700 \times 700-800\mu$  diam.; ostioles prominently papillate. Asci cylindric, short stipitate,  $140-260 \times 7-8\mu$ , stipes  $23-78\mu$ ; ascus plugs constricted. Spores elongate navicular with one side flat, with broad obtuse appendages on each end, dark brown,  $5.5-13.5 \times 18.5-36.5\mu$ , ave.  $10.2 \times 25.3\mu$ . germ slit on convex side of the spore.

*Material examined*: Cooke 255; on *Abies concolor*, Sisson Southern Trail, Mt. Shasta, California, U.S.A., (1947), (AA). Martin 1566; San Blás, Nayarit, Mexico, (1962). Rehm 274; on *Pinus mughus*, Kuhteil, Tyrol, Italy, (1874), (NYBG). Seaver & Bethel; Tolland, Colorado, U.S.A., (1910), (NYBG). Seaver & Shope 32; on *Abies lasiocarpa*, Middle Boulder Canyon, Colorado, U.S.A., (1929) (NYBG), sub *Creosphaeria pinea* Petrak.

*Cultural Characters* (Plate III: 6):

Germination pattern free spreading. Colonies canescent, appressed and sodden, strongly zonate, dull white or colourless. Margin not distinct, entire, peripheral hyphae lying together. Stain absent. Carbonization extensive, in fleck formation. Growth at  $25^{\circ}\text{C}$  slow, 2.0 mm./day.

*Microscopic Characters*:

Primary mycelium not diagnostic; maximum diameter of marginal hyphae =  $2.5\mu$ . Secondary mycelium with irregular globose swellings, closely anastomosed,  $2.5-5.0\mu$  diam.

*Conidiophores and conidia* (Fig. III: 2):

Conidiophores are produced on dull brown ropy pulvinate coremia of the *Graphium* type that are only known at present from culture. The coremia measure  $450-500$  wide  $\times$   $350-600\mu$  high. The conidiophores are not clearly distinguishable, comprising indefinitely branched systems  $450-600\mu$  long, though the branches are restricted to the upper portion of the main axes, which are about  $3\mu$  in diameter. The branching is characteristically ternate, and the fertile branches measure  $15-50 \times 1.8-2.5\mu$  with conidia emerging pleurogenously from geniculate protrusions. The conidia are sessile, clavate, with truncate bases, fawn-brown *en masse*,  $1.6-1.8 \times 3.7-5.0\mu$ , ave.  $1.7 \times 4.3\mu$ .

**22. *Hypoxylon glandiformis* (E. & E.) Martin, nov. comb.**

sub *Rosellinia glandiformis* E. & E. Ellis, J. B. & B. M. Everhart. Proc. Nat. Sci. Philad. **III**, 20, 227, (1890), Ellis, J. B. & B. M. Everhart. North Amer. Pyren. 170, (1892), Ramsey, G. B. Proc. Indiana Acad. Sci. **1914**, 255, (1914).

Stromata globose to pulvinate,  $0.5-1.8 \times 0.5-15.0 \times 0.4-0.7$  mm., dull black. Subiculum absent. Basal tissue slight, dull black. Perithecia 1-30 per stroma, evident to the bases to partially or vaguely evident, globose,  $400-500 \times 500-600\mu$  diam; ostioles indistinctly papillate, minute and inconspicuous. Asci cylindric, reported by Ellis & Everhart as  $100-114 \times 8-10\mu$ . Spores elliptic, equilateral or inequilateral with one side gibbous, pale brown with prominent hyaline sheaths,  $5.0-12.5 \times 13.0-22.5\mu$ , ave.  $8.0 \times 16.9\mu$ .

*Material examined:*

sub *Hypoxylon glandiformis*. Martin 1160; Lake Ozark, Mo. U.S.A., (1962).  
sub *Rosellinia glandiformis*. Ellis; on *Rhus venenata*, Newfield, N.J., U.S.A.. (1890), (NYBG). Langlois 1768; on *Quercus*, St. Martinsville, Louisiana, U.S.A., (1889), (NYBG). Shear; Monroe, La., U.S.A., (NFC). Zabriskie 262; Long Island, N.Y. State, U.S.A. (1889) (NYBG).

*Cultural Characters:*

Germination pattern radiate. Colonies canescent, appressed uniform with colourless sterile mycelium, covered over profusely by grey conidia. Margin entire, not distinct; peripheral hyphae lying together. Stain and carbonization absent. Growth at 25°C slow, 1.00 mm./day.

*Microscopic Characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $0.9\mu$ . Secondary mycelium absent.

*Conidiophores and conidia* (Fig. III: 4):

Conidiophores comprising large units  $500-600\mu$  long, dichotomously or ternately branched to the second degree with the primary axes  $2-3\mu$  diameter, bearing subordinates over their entire length. Fertile branches relatively short,  $15-60 \times 2.2-3.1\mu$ , with the distal parts regularly geniculate; borne at varying angles to the supporting axis or in a more regular trident formation. Conidia sessile, broad oval with wide truncate bases, cineraceous grey *en masse*,  $2.2-2.5 \times 2.7-3.1\mu$ , ave.  $2.3 \times 3.0\mu$ .

**23. *Hypoxylon ludovicianum* Ellis & Everhart ex Martin, nov. sp.**

Stromata pulvinate to aplanopulvinate,  $0.4-5.5 \times 0.4-17 \times 0.7-1.2$  mms., dull black at maturity. Basal tissue slight, dull brown to black. Perithecia one to several per stroma, evident entirely or only to the vertices,

hemispheric,  $400-1100 \times 400-900\mu$ ; ostioles medium papillate or minute and very hard to see. Asci not seen. Spores oval elliptic, inequilateral with one side gibbous or straight, pale to medium brown,  $4.5-7.0 \times 10.0-16.5\mu$ , ave.  $5.8 \times 12.3\mu$ .

Ellis notes on the packet in his herbarium that this species is possibly not distinct from *Rosellinia subiculata* (*H. chrysoconium*). On superficial examination the main difference appears to lie in the absence of subiculum in this species.

*Material examined:*

sub *Hypoxylon ludovicianum*. Martin 1718; Savoy State Forest, Mass., U.S.A., (1963). Martin 1820; ex Rogerson, Ulster Co., N.Y. State, U.S.A., (1963).  
sub *Rosellinia ludoviciana* Ellis and Everhart, ined? Kramer in Kansas S.C. Herb. 13; Leavenworth, Kansas, U.S.A., (NYBG), (1958). Langlois; Flora ludoviciana 299 in Ellis Herb., on *Salix*, Point à la Hache, La., U.S.A., (1886), (NYBG).

*Cultural Characters:*

Germination pattern radiate. Colonies felty to velvety, sometimes somewhat gelatinous, growing freely with a fine texture, dull or pure white. Margin distinct, entire, with peripheral hyphae compact. Stain absent or olivaceous green; carbonization always absent. Conidia appear immediately or at least by 7 days, so that the colony turns pale grey. This is in contrast to *H. chrysoconium* where the conidia develop later and are not as conspicuous.

*Microscopic Characters:*

Primary mycelium undiagnostic; marginal hyphae with a maximum diameter of  $1.8\mu$ . Secondary mycelium with subseptate swellings, variable in occurrence, and arranged loosely with hyphae  $2.2-3.0\mu$  in diameter.

*Conidiophores and conidia* (Fig. III: 5):

Conidiophores not clearly distinct, dichotomously or ternately branched over most or all of the primary axes to the first or second degree,  $370-600 \times 1.5-3.7\mu$ . Fertile branches variable in length,  $27-122 \times 1.5-3.1\mu$ , conspicuously warted, always geniculate, and lying at a variable angle to the supporting axes. Conidia pleuracrogenous, sessile, subglobose to oval, broad or narrow based, pale grey,  $1.8-3.1 \times 2.5-5.0\mu$ , ave.  $2.6 \times 4.0\mu$ .

24. *Hypoxylon chrysoconium* B. & Br.

Berkeley, M. J. & C. E. Broome Jour. Linn. Soc. **14**, 120, (1875), Miller, J. H. World Species of *Hypoxylon* 54, (1961), Petch, T. Ann. Roy. Bot. Gard. **8**, 160, (1924).

sub *Rosellinia subiculata* (Schw.) Sacc. Ferdinandsen, C. & O. Winge Bot.

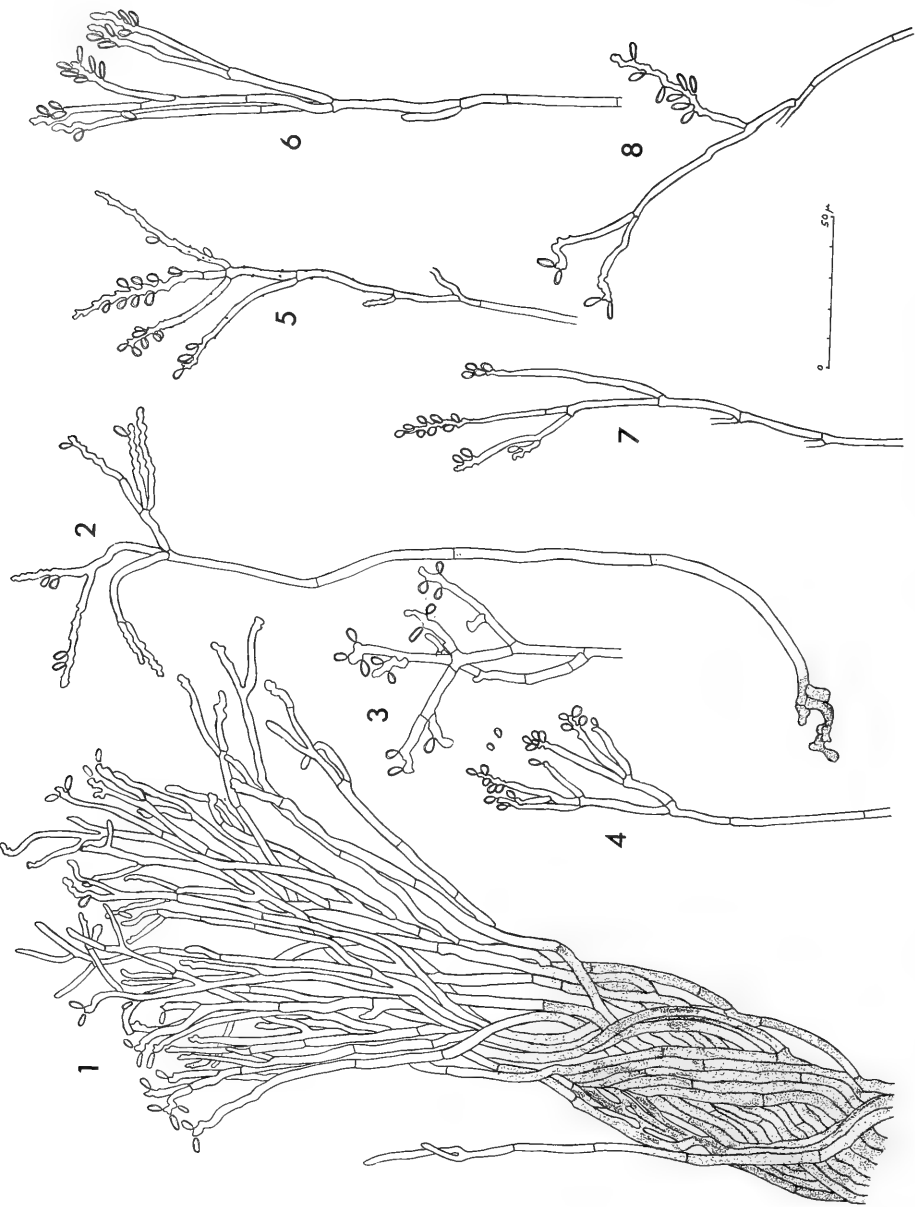


FIG. III. Conidiophores and Conidia. *Nodulisporium* type II.

1. *Hypoxylon necatrix*: *Graphium*-type coremium.
2. *Hypoxylon necatrix*: Whole conidiophore for comparison, showing basal attachment.
3. *Hypoxylon necatrix*: Whole conidiophore for comparison, showing basal attachment.
4. *Hypoxylon necatrix*: Whole conidiophore for comparison, showing basal attachment.
5. *Hypoxylon ludovicianum*.
6. *Hypoxylon illium*.
7. *Hypoxylon necatrix*: Whole conidiophore for comparison, showing basal attachment.
8. *Hypoxylon necatrix*: Whole conidiophore for comparison, showing basal attachment.

Tidskrif, **29**, 17, (1909), Miller, J. H. Mycologia **20**, 327, (1928), Nowell, W. West Indian Bull. **16**, 48, (1916), Parks, H. E. Univ. Calif. Publ. Bot. **12**, 51, (1926), Ramsey, C. B. Proc. Indiana Acad. Sci. **1914**, 256, (1914), Rehm, H. Hedwigia **21**, 132, (1882), Rick, J. Broteria ser. cienc. nat. **1**, 187, (1932), Theissen, F. Beih. Bot. Cent. **27**, 394, (1910), Weir, J. R. U.S.D.A. Bull. **1380**, 92, (1916).

sub *Sphaeria subiculata* Schw. Schweinitz, L. v.d. Synops. Fung. Carol. Sup. **44**, (1822).

Stromata globose, pulvinate or aplanopulvinate depending on the number of perithecia per stroma,  $0.6-8 \times 0.6 \times 0.4-1.1$  mm., deep black at maturity (Plate I: 2). Subiculum crustose, densely branched, closely anastomosed but not sheathing the stromata, bright yellow to orange. Initial layer (ectostroma) white or fawn-brown, persistent though merging with carbonous layer of the entostroma. Basal tissue slight, dull brown to black. Perithecia one to several per stroma, usually evident to the bases though sometimes coalesced to the vertices, globose or hemispheric,  $500-800 \times 500-900\mu$ ; ostioles medium papillate. Asci cylindric, short stipitate,  $90-200 \times 7-12\mu$ , stipes  $30-114\mu$ . Spores oval elliptic, inequilateral with one side gibbous, dark brown,  $4.5-7.0 \times 7.5-14.5\mu$ , ave.  $5.8 \times 11.1\mu$ .

*Material examined*: Doty 11279, 11393: Raroia Atoll, Tuamotu Archipelago, (1952), (NYBG). Martin 1624, 1623; Nyack, N.Y. State, U.S.A., (1963). Martin 1650, 1651, 1652; Roxbury, Conn., U.S.A., (1963). Martin 1718; Savoy State Forest, Mass., U.S.A., (1963). Rogers 3128; on *Bambusa*, Lauai, Hawaii, (1947), (NYBG).

#### *Cultural Characters:*

Germination pattern radiate. Colonies velvet felty, growing freely with a fine texture, uniform to strongly zonate, pure white, often gleaming, sometimes discoloured ochre. Margin usually not distinct, lobed or entire, with peripheral hyphae lying close together. Stain and carbonization absent. Growth at  $25^{\circ}\text{C}$  very slow,  $0.56-1.60$  mm./day.

#### *Microscopic Characters:*

Primary mycelium undiagnostic; marginal hyphae have a maximum diameter of  $1.8\mu$ . Secondary mycelium absent.

#### *Conidiophores and conidia* (Fig. III: 7):

Conidiophores not clearly distinct from the vegetative mycelium, dichotomously or ternately branched to the second degree or indefinitely over most or all of the primary axes,  $180-600 \times 1.5-2.2\mu$ . Fertile branches variable in

length,  $19-112 \times 1.2-2.2\mu$ , lying at a variable angle to the supporting axes or in trident formation, with the conidial portion smooth, irregular or geniculate in outline. Conidia pleuracrogenous in small groups, sessile, subglobose, with wide truncate bases, white *en masse*,  $1.2-2.5 \times 2.2-3.7\mu$ , ave.  $1.9 \times 2.8\mu$ .

25. *Hypoxylon illitum* (Schw.) Curt.

Curtis, M. A. Geol. and Nat. Hist. Survey of N.C., III 140, (1867), Ellis, J. B. & B. M. Everhart Jour. Myc. 4, 109, (1887), North Amer. Pyren., 654, (1892), Miller, J. H. World Species of *Hypoxylon* 83, (1961), Shear, C. L. Lloydia 10, 63, (1947).

sub *Sphaeria illita* Schw. Schweinitz, L. v.d. Trans. Amer. Phil. Soc. Philad., N.S. 4, 192, (1832).

Stromata globose, pulvinate or aplanopulvinate, depending on the number of perithecia,  $1.1-19 \times 1.1-33 \times 0.9-1.8$  mm. dull black. Ectostroma continuous or disappearing abruptly over the ostioles to leave small annulate discs 0.5 mm. in diameter, and thereby exposing the carbonous outer ectostroma. Basal tissue slight, dull black. Perithecia one to several per stroma, evident to the bases, partially evident, or completely immersed, globose to broad ovate,  $700-1000 \times 800-1000\mu$ ; ostioles prominent papillate, frequently beak-shaped. Asci cylindric, inequilateral, crescentic or with one side flat, amber to pale brown,  $3.0-4.5 \times 10.0-12.5\mu$ , ave.  $3.8 \times 11.3\mu$ . This species like *H. albocinctum* and *H. cuneosporum*, is easy to confuse with *H. serpens*. The main differentiating character is the nature of the spores.

*Material examined*: Demetrio 56; on *Ulmus americana*, Mo., U.S.A., (1887), (NYBG). Martin 1127, 1129, 1130, 1131; Lake Ozark, Mo., U.S.A., (1962).

Miller; on *Platanus occidentalis*, Princeton, Ga., U.S.A., (1928), (AA).

*Cultural Characters*:

Germination pattern free spreading. Colonies velvet felty, growing free with a fine texture, strongly zonate, pure white. Margin not distinct, lobed, with the peripheral hyphae lying together. Stain none, carbonization none. Growth at 25°C very slow, 1.20 mm./day.

*Microscopic Characters* (Fig. III: 6).

Primary mycelium undiagnostic. Marginal hyphae have a maximum diameter of  $2.3\mu$ . Secondary mycelium loosely organised, uniform,  $1.5-2.5\mu$  diam.

*Conidiophores and conidia*:

Conidiophores distinct, branched dichotomously or ternately to the first or second degree near the apex of the primary axes,  $110-170 \times 3\mu$ . Fertile branches  $20-78 \times 1.5-2.3\mu$ , not noticeably geniculate though irregular in outline, and lying free from the supporting axes. Conidia pleuracrogenous,



sessile, cylindric or clavate with wide truncate bases, white *en masse*,  $2.5-3.2 \times 6.1-8.9\mu$ , ave.  $3.3 \times 7.3\mu$ .

26. *Hypoxylon mammatum* (Wahl) Miller.

Miller, J. H. World Species of *Hypoxylon* 64, (1961).

sub *Entoleuca callimorpha* Syd. Sydow, H. & F. Petrak. *Annales Mycologici* 20, 186, (1922).

sub *Hypoxylon blakei* Berk & Curt. Berkeley, M. J. *Grevillea* 4, 52, (1875).

sub *Hypoxylon holwayi* Ellis. Cooke, M. C. *Grevillea* 11, 130, (1883), Ellis, J. B. Amer. Nat. 17, 193, (1883), Ellis, J. H. & B. M. Everhart. Jour. Mycol. 4, 67, (1888).

sub *Hypoxylon morsei* Berk & Curt. Berkeley M. J. *Grevillea* 4, 51, 1875. Lloyd C. G. Myc. Writ. 7, 1314, (1924), Lloyd C. G. Ibid. 7, (1354), Miller, J. H. *Mycologia* 20, 320, (1928), Traverso, J. B. *Flora Ital. Crypt.* 1, 47, (1906).

sub *Hypoxylon pauperatum* Karsten. Bresadola, G. & P. A. Saccardo. *Malpighia* II, 294, (1897), Karsten, P. A. *Mycologia fennica* II. *Pyrenomycetes* 42, (1873). Rehm, H. *Ann. Mycol.* II. 395, (1913).

sub *Hypoxylon pruinatum* (Klotze) Cke. Cooke, M. C. *Grevillea* II, 130, 1883. Currey, F. Trans. Linn. Soc. Lond. 22, 226, (1859), Ellis, J. B. & B. M. Everhart North Amer. Pyren. 639, (1892), Povah, A. *Phytopathology* 14, 140—145, (1924), Schreiner, E. J. *Mycologia* 17, 218—220, (1925).

Stromata superficial or erumpent from bark as in *H. ravenelii*, aplanopulvinate or aplanate,  $1.5-7 \times 1.8-00 \times 1.8-7$  mm. Ectostroma white, at first continuous, late becoming granulate and persisting feebly at maturity or merging with the entostroma and turning dull grey black. Carbonous layer of entostroma massive, deep black, basal tissue well developed, corky, dull white to dull brown. Perithecia rarely solitary, usually between 5 and an indefinite number per stroma, vertices evident or only vaguely so, usually appearing polygonal and somewhat straight-sided in horizontal outline,  $800-1300 \times 700-1200\mu$ ; ostioles papillate, ranging from very small to highly prominent. Spores elliptic to nearly cylindric, equilateral, medium to dark brown,  $5.0-14.0 \times 15.0-31.5\mu$  ave.  $9.3 \times 23.2\mu$ .

*Material examined:*

A large quantity of material in the Helsinki and Ann Arbor Herbaria. Davidson; on *Populus tremuloides*, N.B. Canada, (FBLNB). Davidson in FPF 395; on *Alnus* sp., Southbrooke, Nfld., Canada, (FBLNB). FBLA C281 (= Martin 620); Stanley, on *Populus tremuloides*, Shaftesbury, Alberta, Canada, (1961), (FBLA). FBLBC 847, 850, (= Martin 619a); on *Quercus*

*rubra*, Petawawa Forest Experimental Station, Ontario, Canada, (1961), (FBLBC). FBLBC 9307; on *Populus tremuloides*, Revelstoke, B.C., Canada, (FBLBC). FPF 366; on *Salix* sp., Pasadena, Northfield, Nfld., Canada, (FBLNB). FPF 2961; on *Salix* sp., Rossfield Crossing, Picton, N.S., Canada, (FBLNB). Martin 1700; Mt. Toby, Mass., U.S.A., (1963). Martin 1722; Savoy State Forest, Mass., U.S.A., (1963).

#### *Cultural Characteristics:*

Germination pattern free spreading. Colonies felty, growing free with a fine texture, uniform, purple brown with a grey surface eventually due to the production of conidia. Margin not distinct, entire, with the peripheral hyphae lying close together. Stain dull buff brown; carbonization absent. Growth at 25°C very slow, 1.00 mm./day.

#### *Microscopic Characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $2.3\mu$ . Secondary mycelium closely anastomosed, uniform,  $1.8-4.3\mu$  diam.

#### Imperfect Stage (Fig. III: 8):

sub *Hypoxylon holwayi* Ellis. Ellis, J. B. Amer. Nat. **17**, 193, (1883), Gruenhagen, R. H. Phytopathology **35**, 72—89, (1945), Ponomareff, N. V. Phytopathology **28**, 515—518, (1938).

Conidiophores not clearly distinct from the vegetative mycelium,  $210-540 \times 1.8\mu$ , dichotomously or ternately branched indefinitely over the upper segments of the primary axes which are normally very broad in diameter. Fertile branches  $11-25 \times 1.5-1.8\mu$  lying freely, geniculate. Conidia in short spicate pleuracrogenous or acrogenous clusters, sessile, elliptic to clavate with narrow truncate bases, white en masse,  $1.2-3.0 \times 5.6-8.4\mu$  ave.  $2.8 \times 7.4\mu$ .

#### DISCUSSION AND CONCLUSION:

The reasons for the separation and establishment of the section *Entoleuca* from the other groups of the genus *Hypoxylon* were discussed in a previous paper (Martin, 1967b). The writer believes that the former exclusion of many species from *Hypoxylon* on the grounds of perithecial number is an arbitrary distinction. The question that arises is whether by merging them we have created a natural group. The resolution of this problem is always likely to be subjective, but it is interesting upon analysis to find that there are in fact several conflicting patterns of organization among the species. These are best expressed in the following table.

In Group I belong all the large spored, dark subiculate members of the former genus *Rosellinia*. Many of these produce *Graphium* type coremia. Species

## SPECIES GROUP

## CHARACTER

<p>Basal tissue slightly developed, white or dull coloured (Fig. 1 : 2)</p>	<p>Ascal plugs constricted, spores large elongate elliptic; ± subiculum of dark hyphae and ascospore appendages; colonies usually rapidly eroded, germ slit usually on convex side of ascospore</p>	<p>Colonies silky or felty, uniform, ± mottled; carbonization; <i>Graphium</i> type coremia often present. Conidiophores normally stout</p>	<p>Germination pattern free spreading</p>	<p>Stromata 1—few peritheciate</p>	<p><i>H. aquilum</i> <i>H. aridicolum</i> <i>H. corticum</i> <i>H. thelemum</i></p>	I A
		<p>Colonies caescent, uniform, rough granulate with age.</p>	<p>Germination pattern radiate</p>	<p>Stromata 1—α peritheciate</p>	<p><i>H. dialthrastrum</i></p>	I B
		<p>Colonies caescent, normally uniform with rapid and profuse conidial formation, no coremia, conidiophores slender</p>	<p>Germination pattern free spreading</p>	<p>Stromata 1—α peritheciate</p>	<p><i>H. perusensis</i> <i>H. ravenelli</i> <i>H. glandiformis</i> <i>H. ludovicianum</i></p>	I I A I I B
	<p>Ascal plugs straight or slightly curved; spores normally of small or moderate size, if 17 u long then not elongate elliptic; subiculum of dark hyphae lacking, ascospores often delayed; colonies growing at a slow or moderate rate, germ slit on concave side of ascospore.</p>	<p>Colonies velvety or felty, often stimate, conidia delayed; no coremia; conidiophores slender</p>	<p>Germination pattern radiate</p>	<p>Stromata 1—few peritheciate</p>	<p><i>H. cuneosporum</i> <i>H. regale</i> <i>H. serpens</i> <i>H. chrysoconium</i> <i>H. masoideum</i> <i>H. minutissimum</i></p>	I I C I I I A
<p>Basal tissue well developed, dull coloured</p>				<p>Nodulispore type I</p>	<p><i>H. albocinctum</i> <i>H. pynerthii</i> <i>H. adumbrato</i> <i>H. illium</i> <i>H. smilactacolum</i></p>	I I I B
	<p>Basal tissue well developed, conspicuously white or pink coloured (Fig. 1 : 1)</p>		<p>Germination pattern free spreading</p>	<p>Stromata few—α peritheciate</p>	<p><i>H. mammatum</i></p>	I I I C
					<p><i>H. sasafra</i> <i>H. cadagras</i> <i>H. discolor</i></p>	I V
					<p>Nodulispore type I</p>	<i>H. entoleucum</i>

not considered here that should probably be included comprise *H. acuminosporum*, *H. asperatum*, *H. bunodes*, *H. buxi*, *H. gigasporum*, *H. pulcherrimum*, *H. radiciperdatum* and *H. rostrisporum*.

In Group II and III belong the bulk of the members of *Rosellinia* and *Hypoxylon* with small to medium sized black stromata that produce canescent to velvety colonies in culture. Species that ought probably to be included here comprise *H. albolanatum*, *H. apiculatum*, *H. bicoloratum*, *H. callimorphum*, *H. confluens*, *H. culmorum*, *H. folicola*, *H. geasteroides*, *H. grandineum*, *H. griseocinctum*, *H. herpotrichiodes*, *H. julii*, *H. langloisii*, *H. mammiformis*, *H. medullaris*, *H. megalocarpum*, *H. megalosporum*, *H. morgani*, *H. mutans*, *H. mummularioides*, *H. poliosum*, *H. protuberans*, *H. quadratum*, *H. rosellinioides*, *H. sphaeristomum*, *H. subacutum*, *H. subaenum*, *H. sublimbatum*, *H. tassianum* and *H. victoriae*.

In Group IV belong many members of the former genus *Penzigia*, together with others in *Hypoxylon* that are similar in having a well developed white or brightly coloured basal tissue. Species that should probably be included here comprise *H. bermudensis* and *H. citrinum*.

When further information is available, it should be possible to say whether this classification is sufficient or whether it should be improved upon.

### *Latin Diagnoses of New Species.*

#### 2. *Hypoxylon aridicolum* Martin nov. sp.

Stromata globosa aut pulvinata, cum uno aut duo perithecia, gregaria in subiculo fusco in ligno mortuo. Perithecia magna globosa,  $1500-200 \times 1200-1700\mu$ . Asci non visi. Sporae ellipticae, acutae, inaequis lateribus, pallidae fuscae,  $4.5-9.0 \times 14.0-24.0$ , medius  $6.8 \times 18.7\mu$ .

#### 6. *Hypoxylon cuneosporum* nov. sp.

Stromata aplanopulvinata, globosa, 5–20 mm. lata, in exteriore ligno; nigra obscura; entostroma interiora conspicua alba. Perithecia globosa,  $300-400 \times 500-600\mu$ , ostiola papillata; asci cylindrici, cum ferme longis stipitis  $90-150 \times 6\mu$ ; stipes  $35-75 \times \mu$ . Spores ovalae, ferme inaequis lateribus cum uno termino conico, pallidae fuscae,  $3.5-7.0 \times 9.5-14.5\mu$ , medius  $5.0 \times 11.7\mu$ .

#### 12. *Hypoxylon entoleucum* Martin nov. sp.

Stromata aplanata, crustata, praecipue mollis 0.6 mm. altitudo cum superficie car-bonaceo. Perithecia prominentes, aggregata sed non coalescentes. Entostroma interiora conspicua alba et magna aucta. Perithecia globosa,  $400-650 \times 400-500\mu$ , ostiola obscura papillata. Asci non visi. Sporae ellipticae, navicularae, pallidae fuscae,  $5.0-8.5 \times 14.0-19.0\mu$  medius  $6.4 \times 16.4\mu$ .

#### 13. *Hypoxylon minutissimum* Martin nov. sp.

Stromata minuta, globosa, nigra obscura, cum perithecio singulo, sed gregaria in ligno decorticato. Perithecia  $200-300 \times 1500-250\mu$ ; ostiola papillata confusa. Asci clavati, breves stipitati,  $75-90 \times 8\mu$ , stipes  $18-21 \times 3\mu$ . Sporae ovalae subglobosae, pallidae fuscae,  $5.0-8.0 \times 6.0-10.5\mu$ , medius  $6.2 \times 8.5\mu$ .

#### 17. *Hypoxylon adumbratum* Martin nov. sp.

Stromata ferme cum crebris peritheciis, aplanata-effusa, sed aliquando pulvinata cum singulo aut paucis peritheciis, nigra nitensque. Perithecia magna  $750-1200 \times 700-2000\mu$ . Ostiola papillata ferme fastigata, saepe circumplecta ab iugis superficialis. Asci cylindrici, cum longis stipitis,  $180-250 \times 6\mu$ ; stipes  $100-170\mu$ . Sporae ovalae inaequis lateribus, navicularae, obscurae fuscae,  $3.5-7.0 \times 11.0-16.0\mu$ , medius  $5.3 \times 13.1\mu$ .

23. *Hypoxylon ludovicianum* Martin nov. sp.

Stromata pulvinata aut aplanapulvinata, nigra obscura, cum perithecio singulo aut multis peritheciis. Perithecia hemisphaerica,  $400-1100 \times 400-900 \mu$ ; ostiola papillata vel minuta. Asci non visi. Sporae ovalae, ellipticae, inaequis lateribus, pallidae fuscae,  $4.5-7.0 \times 10.0-16.5 \mu$ , medius  $5.8 \times 12.3 \mu$ .

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#### BOOK REVIEW

FOSSIL GYMNOSPERM WOODS IN HUNGARY FROM THE PERMIAN TO THE PLIOCENE  
by Pál Greguss pp. 136 + 670 microphotographs on 86 pages and 14 maps.  
Budapest: Akadémiai Kiadó 1967) \$8.80.

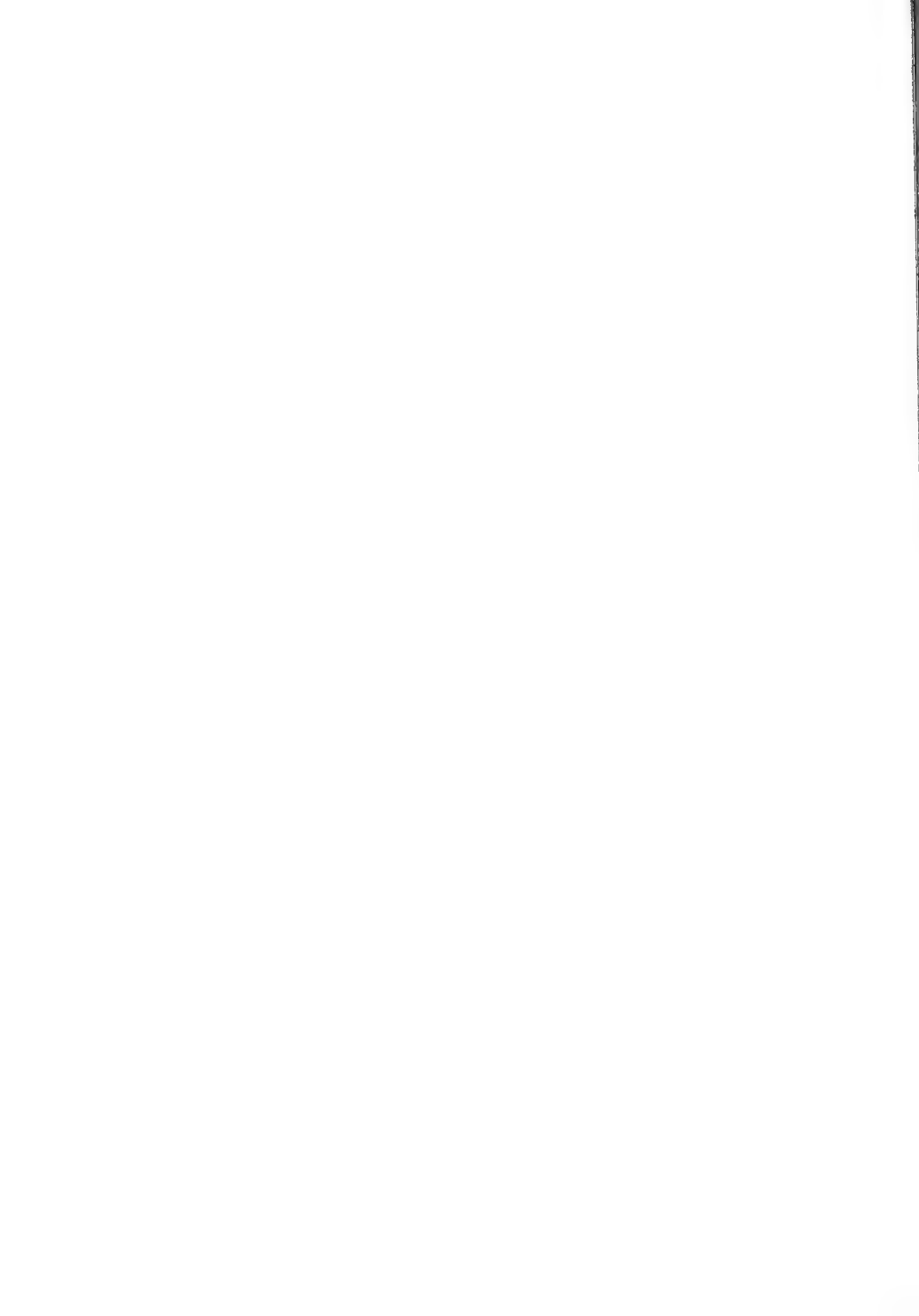
In order to reach as many readers as possible the work is published in English from a translation by S. Országh. The author, Prof. Dr. P. Greguss, is no newcomer to this exacting field of study for, over the years, he has produced several substantial publications on the xylotomy of both fossil and living species of gymnosperm.

The book contains a comprehensive palaeoxylotomic survey of the gymnospermous wood remains of the period stated in the title. For the most part it consists of systematic descriptions of the well illustrated fossils in cross section, radial section and tangential section. Seven families and about 30 genera are represented.

The monograph fills a gap in the botanical fossil records of Hungary. It can be claimed that it will be of value in several allied fields. Firstly it has an important bearing on geological and palaeoclimatological studies of the age, and its practical use in local mining undertakings should not be lost sight of: in addition it has a strong educational value for advanced students.

To what degree the value of the treatise would have been enhanced by the reproduction in colour of the 670 microphotos, it is not possible to assess, but it is safe to say it would have raised the price well above the present reasonable level of \$8.80. It is stressed that this work, detailed though it undoubtedly is, presents a preliminary analysis of the material and that the field holds out encouraging prospects for more extensive research. Over 125 references to literature are given to help the reader and lead any future researcher on his way.

R. A. DYER





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**VOL. 34**

Published: 15TH JULY 1968

'n ANATOMIESE EN ONTOGENETIESE  
STUDIE VAN DIE WORTELS VAN

**OMISSION**

JOURNAL OF SOUTH AFRICAN BOTANY, VOL. 34, PART 3, 1968

Please insert facing Plate 1, p. 132.

PLATE 1: Top—A., Bottom, left—C., Bottom, right—B.

The origin and development of adventitious and lateral roots and the structure of contractile roots in some species of the Liliaceae are discussed briefly.

The first adventitious root develops from the hypocotyl of the germinating seed, close to the vascular tissues of the hypocotyl. Before the adventitious root emerges from the hypocotyl an apical meristem, rootcap and vascular tissues differentiate.

Lateral roots arise some distance from the apical meristem of the parent root in the pericycle. The endodermis of the parent root plays no part in the organization of the lateral root primordium. During growth of the young lateral root through the cortex of the parent root, the apical meristem, rootcap, protoderm, ground meristem and procambium are blocked out.

Contraction occurs mostly in adventitious roots and rarely in the radicle of seedlings. It is usually limited to the proximal end of the root. The surface in this region becomes markedly wrinkled.

Contractile roots (or parts thereof) display certain histological modifications. Cells, while contracting longitudinally, expand laterally. In some species the contractile root may become a storage organ.

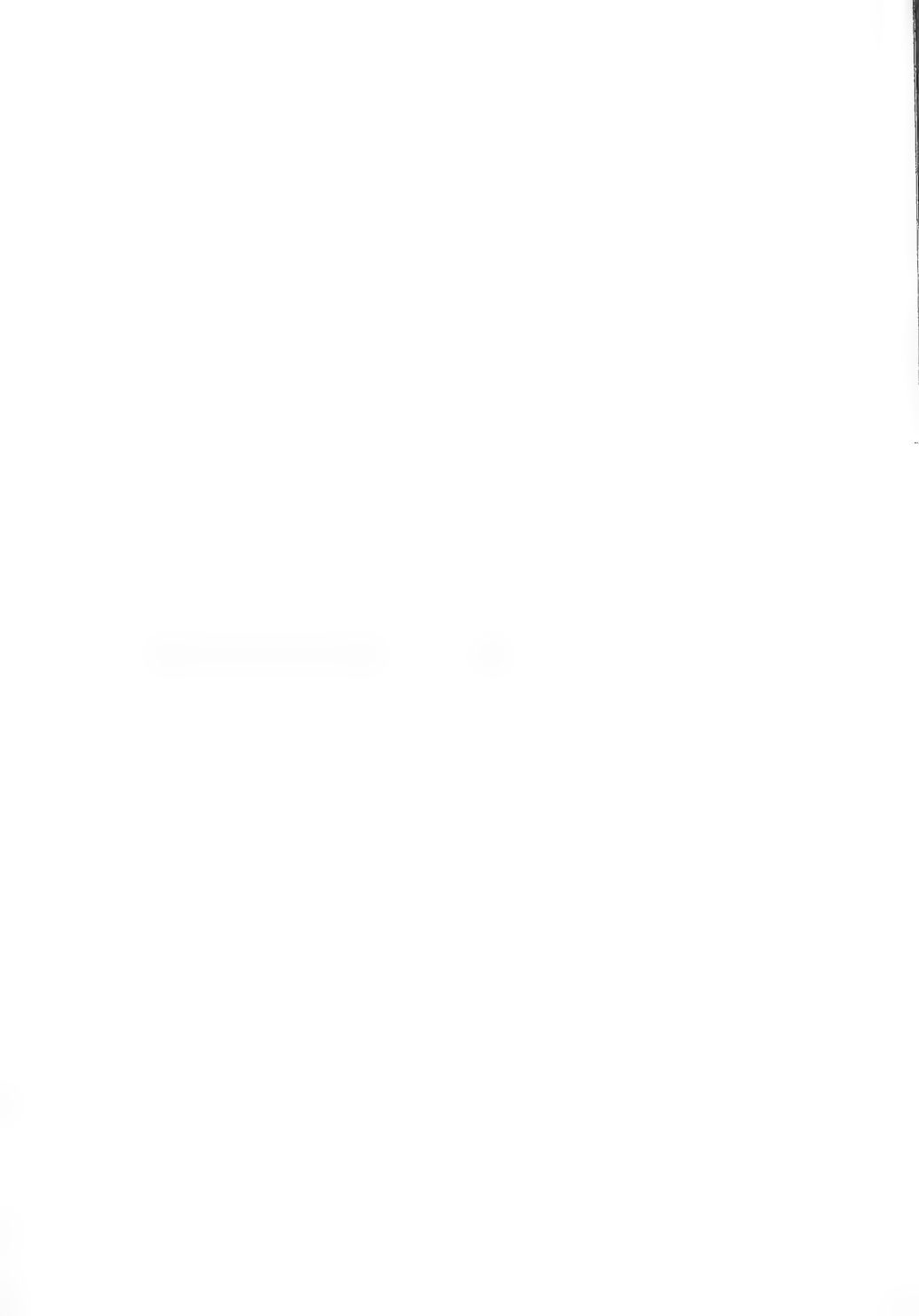
**INLEIDING**

Oor die ontstaan en ontwikkeling van by- en sywortels en die bou van trekwortels by die Liliaceae is nog min navorsing gedoen.

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\* Deel van 'n verkorte weergawe van 'n proefskrif goedgekeur vir die graad van Doktor in die Natuurwetenskappe aan die Universiteit van Stellenbosch, September 1965.

† Aanvaar vir publikasie 22 April 1968.



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'n ANATOMIESE EN ONTOGENETIESE  
STUDIE VAN DIE WORTELS VAN  
SUID-AFRIKAANSE LILIACEAE:  
IV. DIE ONTSTAAN EN ONTWIKKELING VAN BY- EN SYWORTELS  
EN DIE BOU VAN TREKWORTELS.\*†

K. J. PIENAAR

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ABSTRACT

The origin and development of adventitious and lateral roots and the structure of contractile roots in some species of the Liliaceae are discussed briefly.

The first adventitious root develops from the hypocotyl of the germinating seed, close to the vascular tissues of the hypocotyl. Before the adventitious root emerges from the hypocotyl an apical meristem, rootcap and vascular tissues differentiate.

Lateral roots arise some distance from the apical meristem of the parent root in the pericycle. The endodermis of the parent root plays no part in the organization of the lateral root primordium. During growth of the young lateral root through the cortex of the parent root, the apical meristem, rootcap, protoderm, ground meristem and procambium are blocked out.

Contraction occurs mostly in adventitious roots and rarely in the radicle of seedlings. It is usually limited to the proximal end of the root. The surface in this region becomes markedly wrinkled.

Contractile roots (or parts thereof) display certain histological modifications. Cells, while contracting longitudinally, expand laterally. In some species the contractile root may become a storage organ.

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Oor die ontstaan en ontwikkeling van by- en sywortels en die bou van trek wortels by die Liliaceae is nog min navorsing gedoen.

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Die beskikbare literatuur (Rimbach, 1899 en 1929, Arber, 1925 en von Guttenberg, 1940 en 1960) verskaf hoofsaaklik net gegewens oor die algemene trekwortelanatomie en weinig of niks oor die bou en ontwikkeling van by- en sywortels nie.

Die huidige ondersoek is 'n poging om die leemtes in hierdie verband aan te vul.

#### MATERIAAL EN METODES

Sien Pienaar (1968 a, p. 38—39 en b, p. 92—93).

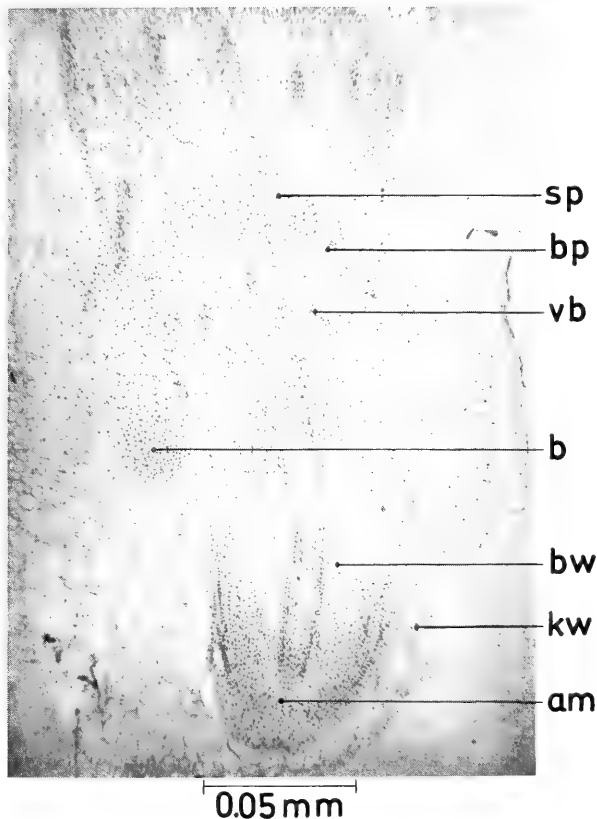


Fig. 1. *Agapanthus pendulus*. Mediane lengtesnee van die hipokotiel met stingel-, blaar- en bywortelprimordia: am, apikale meristeem van die byworteltjie; b, bywortelprimordium; bp, blaarprimordium; bw, byworteltjie; kw, deel van kiemwortel; sp, stingelprimordium; vb, vaatweefsel.

# ONDERSOEK

## A. Bywortels

Die ondersoek is gedoen by *Agapanthus pendulus* (L. Bol.) Leighton (fig. 1).

Die term bywortel word gebruik vir die wortels wat nie ontstaan uit die wortelpool van die embrio nie (vgl. adventiewe wortels in Eames & MacDaniels, 1947, p. 289 en Esau, 1953, p. 472).

By monokotiele sterf die eerste wortel, wat ontwikkel uit die wortelmeristeem

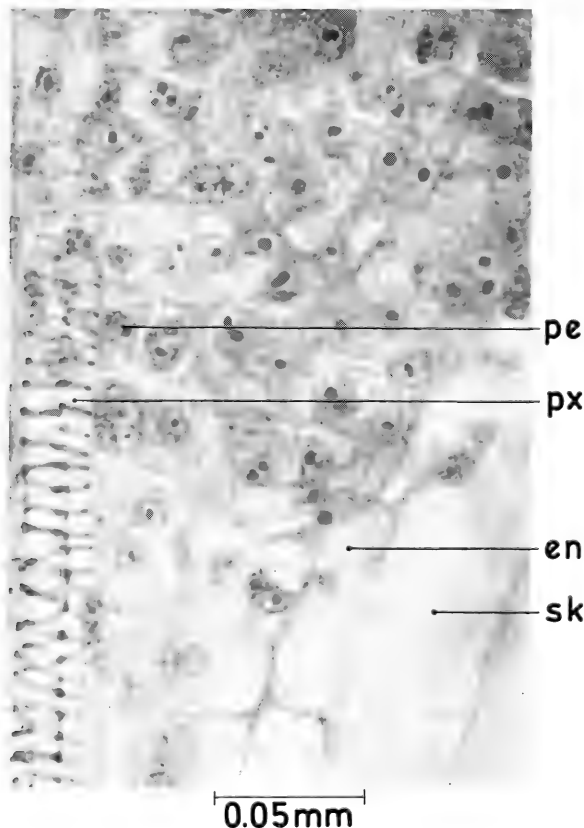


Fig. 2. *Eucomis nana*. Radiale lengtesnee van 'n sywortelprimordium: en, endodermis van die moederwortel; pe, periklinale verdelings van die perisikel om die sywortelprimordium te vorm; px, protoxileemvat en sk, skors van die moederwortel.

van die embryo, vroeg af. Die wortelstelsel van die volwasse plant bestaan gevolglik uit wortels wat ontwikkel uit die as, bokant die plek van oorsprong van die kiemwortel. Hierdie bywortelstelsel mag ryklik vertak wees.

By *Agapanthus pendulus* is waargeneem dat die eerste bywortels uit die hipokotiel van die kiemplantjie ontwikkel. Die bywortelprimordium is endogeen en naby die ontwikkelende vaatweefsel van die hipokotiel geleë. Dit is nie duidelik of die selle, wat oorsprong gee aan die primordium, derivate van die interfassikulêre parenchium is nie.

Die algemene organisasie van die apikale meristeem, die wortelmussie, protoderm, grondweefsel en prokambium kon waargeneem word nog voordat die byworteltjie op die oppervlakte verskyn. Die vaatweefsel van die byworteltjie sluit aan by dié van die hipokotiel deur die vorming van onreëlmatige tracheiedweefsel.

Die manier waarop die bywortel deur die oppervlakkige weefsels van die hipokotiel en die kiemwortel groei, is nie duidelik nie.

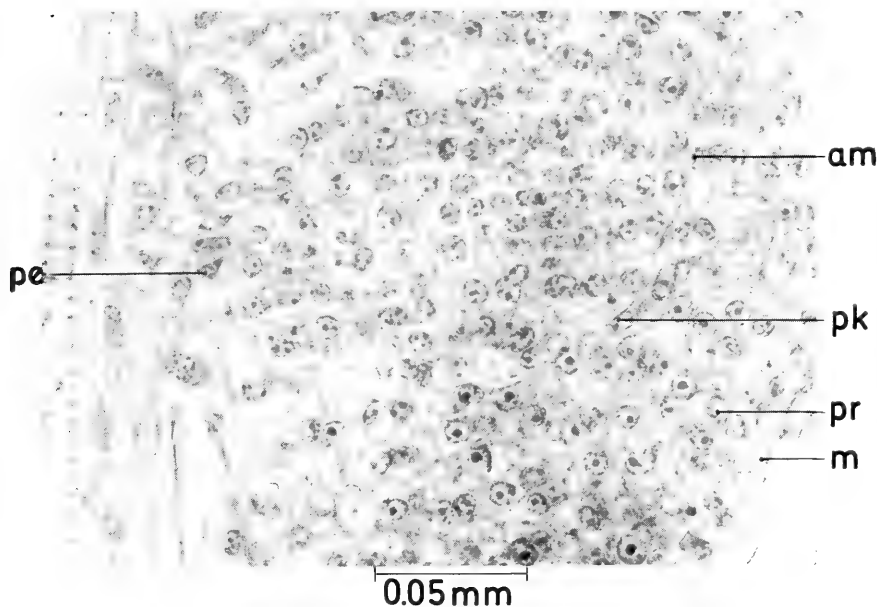


Fig. 3. *Ornithogalum hispidum*. Mediane lengtesnee van 'n ontwikkelende sywortel: am, apikale meristeem; m, wortelmussie; pe, perisikel van die moederwortel waarin periklinale verdelings plaasgevind het; pk, prokambium, en pr, protoderm van die syworteltjie.

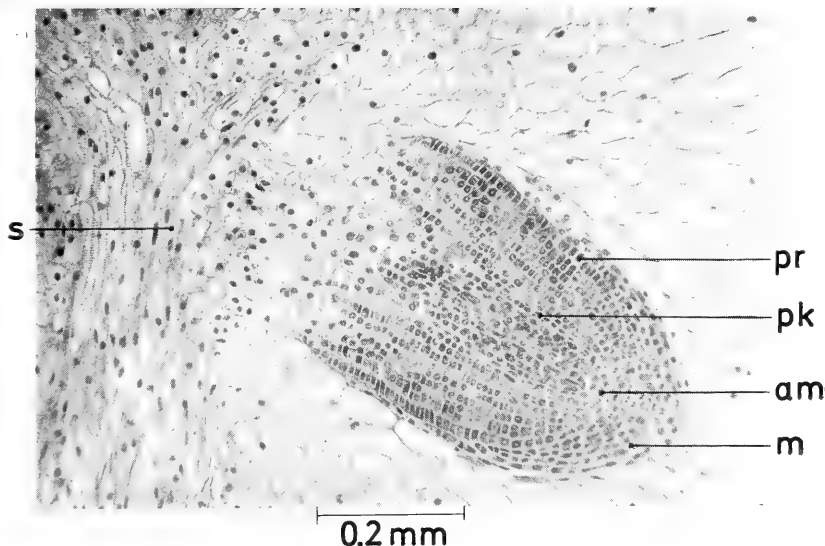


Fig. 4. *Bulbinella robusta*. Mediane lengtesnee van 'n jong syworteltjie: am, apikale meristeem; m, wortelmussie; pk, prokambium; pr, protoderm; s, sentrale silinder van die moederwortel.

## B. Sywortels

Die volgende soorte is ondersoek:

*Bulbine asphodeloides* R. & S.

*Bulbinella robusta* Kunth

*Eucomis nana* Ait.

*Ornithogalum hispidum* Hornem.

Sywortels ontwikkel endogeen uit die bywortels eers nadat die primêre weefsels volkome gedifferensieer is, m.a.w. uit die volwasse bywortels en sowat 1 cm agter die apikale meristeem. Kiemwortels met sywortels is nie waargeneem nie.

Die sywortelprimordium ontstaan as gevolg van die aktiwiteit van die perisikel in die moederwortel. 'n Groepie perisikelselle begin om periklinaal en antiklinaal te verdeel (*Eucomis nana*, fig. 2). Die sywortelprimordium dring deur die skors as gevolg van gedurige groei. Die binneskors van die moederwortel neem nie deel aan die vorming van die sywortelprimordium nie. Voordat die syworteltjie aan die oppervlakte van die moederwortel verskyn, is die apikale

meristeem, die prokambium, protoderm en die wortelmussie reeds afgebaken (*Ornithogalum hispidum*, fig. 3 en *Bulbinella robusta*, fig. 4). Die struktuur van die apikale meristeem stem ooreen met dié van die volwasse wortel (vgl. Pienaar, 1968 a, p. 37—60).

Alhoewel bande van Caspary aanwesig is in die endodermis van die moederwortel van *Eucomis nana*, wou dit voorkom of die endodermis een keer periklinaal verdeel het naby die aanleg van die sywortelprimordium. Bande van Caspary kon waargeneem word in die radiale wande van twee aangrensende sellae. Volgens Esau (1953, p. 499) verdeel die endodermis gewoonlik nie wanneer bande van Caspary reeds ontwikkel het en sommige van die xileemelemente volwasse is nie.

In 'n dwarsnee, bv. by *Bulbine asphodeloides*, is waargeneem dat die sywortelprimordium aangelê word hoofsaaklik voor 'n xileempool. Dit is kenmerkend van 'n wortel wat poliarg is en daarom ook by die wortels van die Liliaceae.

Die vaatsisteme van die moeder- en die sywortel word verbind deur 'n groep

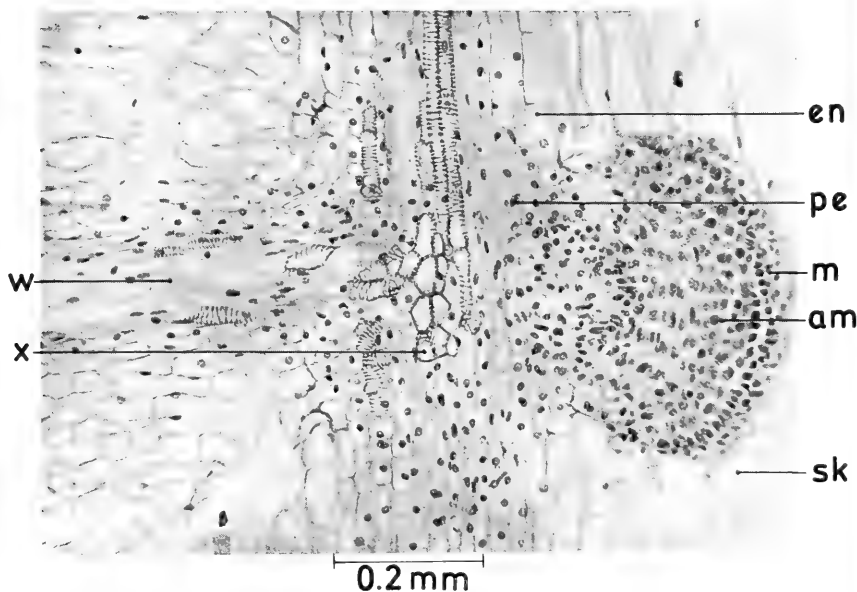


Fig. 5. *Eucomis nana*. Lengtesnee van die moederwortel met 'n ontwikkelende sywortel: am, apikale meristeem; en, endodermis van die moederwortel; m, wortelmussie; pe, perisikel van die moederwortel waarin periklinale delings plaasgevind het; sk, skors van die moederwortel; x, xileem van die moederwortel; w, sywortel wat reeds by die moederwortel uitgetree het.



tussenselle (derivate van die perisikel) wat later ontwikkel in xileem- en floëem-selle (vgl. *Eucomis nana*, fig. 5). Dit wou voorkom of die differensiasie van die vaatweefsel in die jong stadium van ontwikkeling, eerste plaasvind naby die sywortelbasis, d.w.s. in aansluiting met die vaatweefsel van die moederwortel. Dit word opgevolg deur vaatweefsel-differensiasie proksimaal van die apikale meristeem in die sywortel. Gewoonlik sluit die twee vaatweefsels bymekaar aan voordat die sywortel op die oppervlakte van die moederwortel verskyn. Dit hang af van die deursnedikte van die moederwortel en veral dié van die skorsgedeelte. Hoe dikker die wortel, hoe groter is die moontlikheid dat hierdie differensiasie van die aansluitingsweefsel in die syworteltjie voltooi sal wees ten tye van die verskyning daarvan op die oppervlakte van die moederwortel.

### C. Trekwortels

'n Studie van trekwortels en of trekworteldele is in die huidige ondersoek gemaak by:

*Dipidax triquetra* (L.f.) Baker

*Pseudogaltonia clavata* Phillips

*Haworthia truncata* Schönl.

*Agapanthus campanulatus* Leighton

Daar is veral gebruik gemaak van die wortels van jong kiemplantjies. Dit is hoofsaaklik die bywortels wat hierdie spesiale inkrimpingstreek vertoon aangesien die kiemworteltjie baie vroeg afsterf. Dit is tog waargeneem by sommige kiemwortels, bv. by *Dipidax triquetra*.

Die trekwortel is meesal 'n bywortel wat in sy geheel of in 'n spesiale deel daarvan, sekere histologiese afwykings vertoon. Gewoonlik is hierdie afwykings beperk tot ongeveer die eerste cm vanaf die wortelbasis. Uitwendig kan die deel taamlik maklik uitgeken word. Dit is geriffel en aansienlik dikker as die res van die wortel. Geen sywortels kom in hierdie streek voor nie.

### HISTOLOGIESE AFWYKINGS IN DIE TREKWORTELDEEL

Oor die algemeen kom dit voor of die wortel in die trekworteldeel min gedifferensieer het. Die xileemselle is minder verdik en verhout en bestaan hoofsaaklik uit ring- en spiraalvate. Dit is dus moontlik vir hierdie selle om te kan krimp as sekere kragte daarop inwerk. Geen ander verhoutte selle is in die jong trekworteldeel waargeneem nie. Waar die trekwortel meerjarig is en gevolglik sy funksie as inkrimpingsorgaan mettertyd verloor, differensieer dieselfde weefsels as in enige normale meerjarige wortel van dieselfde plant.

'n Kenmerkende eienskap van die trekworteldeel is die groot skorselle, veral die selle van die middelskors. Hierdie weefsel lyk sponsagtig, veral in 'n

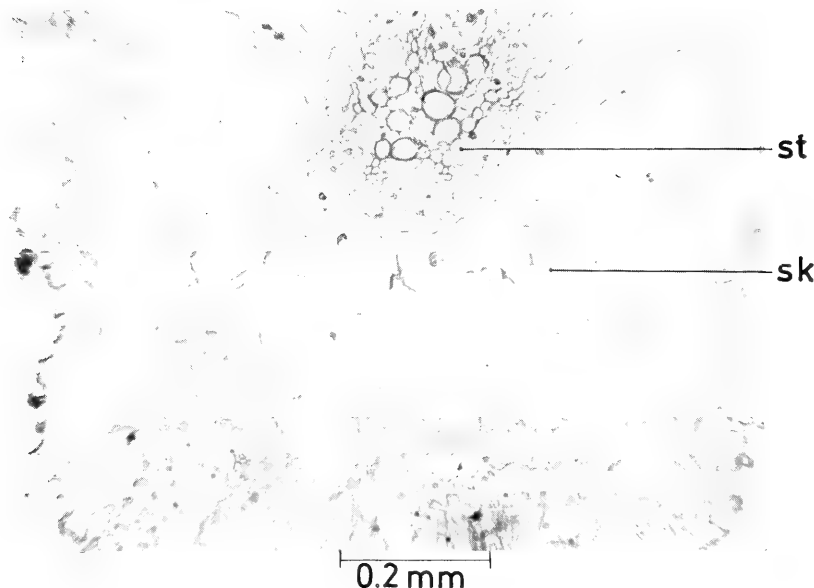


Fig. 6. *Pseudogaltonia clavata*. Dwarssnee van 'n gedeelte van 'n trekwortel: sk, skors; st, stele. Die deursnee van die stele is baie klein in vergelyking met dié van die skors.

dwarssnee, bv. by *Pseudogaltonia clavata* (fig. 6). Die selle is eintlik abnormaal groot en struktureel dus, wat vorm betref, maklik veranderbaar. Die skors is in deursnee ook baie groter as die deursnee van die stele — groter as by die normale wortel.

In die dwarssnee van die wortel van *Pseudogaltonia clavata* (fig. 6), kom dit voor of die inkrimping van die wortel beperk is tot die binneskorsselle. Die buiteskorsselle is inmekaar gedruk en besig om te vergaan.

As gevolg van die lengte-inkrimping van die skorsselle neem hulle radiaal toe in breedte, terwyl die xileemvate begin om kronkelings te vertoon, bv. by *Pseudogaltonia clavata* (fig. 7). In al die wortels wat in hierdie studie ondersoek is, is daar nie 'n geval waargeneem waar die vaatsisteem, as gevolg van die abnormale inkrimping, gebreek is nie.

By sommige soorte staan die inkrimping waarskynlik in verband met die ontwikkeling van die wortel as stoororgaan, bv. by *Haworthia truncata*. Talryke styselkorrels kon in die skors van hierdie wortels waargeneem word. Die oorspronklike trekworteldeel (sowat 1 cm lank) word tot 5 cm lank en 1 cm in deursnee. Die res van die wortel, nader na die punt toe, is sowat 2—3 mm

in deursnee. Die toename in dikte van die stoorwortel is waarskynlik die gevolg van seldeling en selvergroting in die parenchimatiese grondweefsel, veral van die skors (vgl. Tomlinson, 1961, p. 20, in verband met 'n soortgelyke toename in dikte by die stingels van die Palmae). By *Haworthia truncata* vertoon dwarsneë van die stoorgedeelte van die wortel en die normale deel van die volwasse wortel, die volgende strukturele kenmerke:

#### Periderm

'n Kurkmantel, sowat ses sellae breed, kom aan die buitekant van beide die stoorgedeelte en die normale deel van die wortel voor. Die kurkkambium differensieer min of meer uit die buitenste laag skorsselle. Die epidermis is afwesig.

#### Skors

Dit is deurgaans parenchimaties en aansienlik breër in die stoorgedeelte as in die normale deel van die wortel (vgl. Rimbach, 1899). In die stoorgedeelte

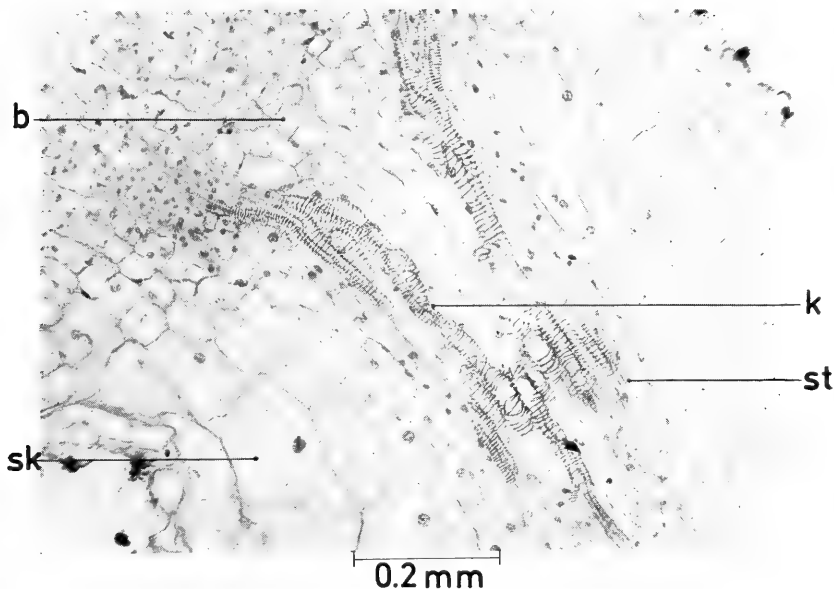


Fig. 7. *Pseudogaltonia clavata*. Mediane lengtesnee van die trekworteldeel in 'n bywortel naby aan die bolbasis: b, bolbasis; k, kronkeling van die xileemelemente; sk, skors; st, stele van die trekworteldeel.

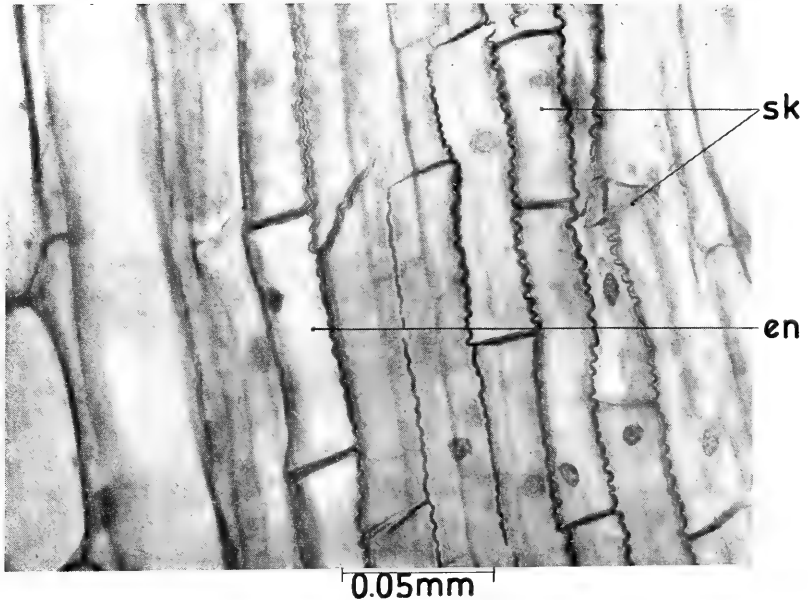


Fig. 8. *Agapanthus campanulatus*. Lengtesnee van die skorsgedeelte van 'n trekwortel: en, endodermis; sk, binneskors. Let op die geriffelde voorkoms van die lengtewande van die skorselle en die buitewande van die endodermiselle.

is die selle meesal baie groot en het plek-plek ineengestort. Die selle besit 'n protoplasmatiese inhoud wat in die stoorgedeelte meer korrelagtig is as in die normale deel van die wortel. Talryke styselkorrels kom voor in die stoorstelle. Die endodermis is in beide gevalle eenlagig en die selwande effens verdik. Bande van Caspary is waargeneem in die radiale wande.

#### *Sentrale silinder*

In die stoorgedeelte is daar meer xileemgroepe as in die normale deel van die wortel (sowat 22 teenoor 12). Die aantal floëmgroepe stem ooreen met die aantal xileemgroepe. Die stoorgedeelte besit enkele verhoude parenchiemselle tussen die metaxileemvate en die groot murggedeelte. By die normale worteldeel is die verhoude parenchiemselle 'n paar lae breed en vorm 'n aaneenlopende mantel tussen die metaxileemvate en die klein murggedeelte.

Die besondere bou van die lengtewande van die binneskorselle van *Agapanthus campanulatus* (fig. 8) verdien spesiale aandag. Die lengtewande is effens verdik, verhout en geriffel. Waarskynlik het hierdie selle klaar gekrimp.

Selfs die buitewande van die endodermis vertoon hierdie eenaardige riffs. Hierdie selle kom soms ook voor in dié dele van die wortel wat eintlik buite die trekwortelgedeelte geleë is.

Dit is duidelik dat die strukturele kenmerke van die weefsels in die trekwortel hulleself leen tot inkrimping. Die manier waarop die inkrimping plaasvind is nie duidelik nie.

#### OPSOMMING EN BESPREKING

##### **Bywortels**

Die eerste bywortelprimordium ontstaan endogeen aan die basis van die hipokotiel en in die onmiddellike nabyheid van die vaatweefsel daarvan. Die struktuur van die apikale meristeem van die byworteltjie en die differensiasie in wortelmussie, protoderm, grondmeristeem en prokambium is waargeneem nadat dit sowat 1 mm uitgegroeï het uit die hipokotiel.

##### **Sywortels**

Sywortels ontwikkel uit die volwasse dele van die bywortels (hier moederwortels genoem).

Die sywortelprimordium ontstaan endogeen as gevolg van periklinale en antiklinale verdelings van groepies perisikelselle in die moederwortel. Die endodermis en die res van die skors van die moederwortel neem nie deel aan die vorming van die sywortel nie.

Die apikale meristeem van die sywortel differensieer in die wortelmussie, protoderm, grondmeristeem en prokambium voordat dit op die oppervlakte van die moederwortel verskyn. Die differensiasie van die vaatweefsel geskied eerste in die aansluitingsweefsel, d.w.s. in die derivate van die perisikel in die moederwortel. Dit word dan gevolg deur differensiasie in die rigting van die syworteltjie.

Die manier waarop die sywortel deur die weefsels van die moederwortel dring, is nie duidelik nie. Volgens von Guttenberg (1940) is die deurdringing altyd meganies van aard.

##### **Trekwortels**

Struktureel is die trekwortelgedeelte eenvoudig deurdat: die xileemelemente net uit ring- en spiraalvate bestaan; die stele, in verhouding tot die skors, klein is; die skorsselle baie groot en plek-plek ineengestort is; slegs enkele verhoude parenchiemselle aanwesig is en sywortels nie in hierdie streek voorkom nie.

Die bou van al die selle is sodanig dat vertikale inkrimping daarvan moontlik is.

Alhoewel die xileemelemente kronkels vertoon, is hulle nooit gebreek nie. As gevolg van die inkrumping het die wortel uitwendig 'n geriffelde voorkoms.

By sommige soorte, bv. by *Haworthia truncata*, kan die trekworteldele van blywende wortels toeneem in dikte. Dit is waarskynlik die gevolg van aanhoudende seldelings in die murg- en veral in die skorsgedeeltes, wat 'n toename in die aantal sellae in hierdie streke veroorsaak. Sulke streke dien moontlik ook vir die stoor van voedsel.

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# A PLANT ECOLOGICAL SURVEY OF THE NOORSVELD†

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## ABSTRACT

The vegetation of the Noorsveld, which is considered to be unique due to the abundance of a succulent spiny, leafless bush, *Euphorbia coerulescens* is described. The area is situated in the 250 mm rainfall area of the Eastern Cape. The soil is generally shallow and fine, and is mainly derived from shales.

Four vegetational strata are distinguished in the Noorsveld. The vegetation was divided into the following 8 communities, according to the abundance values of the major species, which were ranked into a descending order based on their height and aerial cover.

1. *Pappea capensis* Community
2. *Portulacaria afra* Community
3. Tall Mixed Shrub Community
4. *Aloe ferox* Community
5. *Rhigozum obovatum* Community
6. *Euphorbia coerulescens* Community
7. *Pentzia incana* Community
8. *Acacia karoo* Community

The distribution patterns in the Noorsveld of each of the major species, defining a community, are given, as well as a Vegetation Map of the Noorsveld. The structure of each community is briefly discussed.

The relationships of the vegetation in the Noorsveld are considered and special attention is paid to the effects of man and the grazing animal on the developmental process.

## INTRODUCTION

The Noorsveld, as an unique tract of vegetation, has interested botanists and agriculturalists for many years. Despite this interest none or little information regarding the Noorsveld has been forthcoming. The object of this paper is therefore to present a detailed account of this relatively unknown vegetation. The basic vegetational units are given, as well as their distribution, structure and development. On account of the continued and accelerated exploitation of the Noorsveld through farming practices, it is hoped that this study will serve as foundation for further ecological work and to further the aims of veld conservation which was laid down by the Soil Conservation Act of 1946.

The Noorsveld, lying approximately between longitudes 24° 30' E and 25° 25' E and latitudes 32° 44' S and 33° 15' S, is essentially a farming area of about 855 square miles. It is the centre of the Angora goat industry and includes portions of the magisterial districts of Jansenville and Somerset East.

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in the south by the Klein Winterberg, Klein Winterhoek and the Suurberg Mountains. The undulating, almost monotonous plain, extends in a east-west direction and supports the main area of the Noorsveld. The plain itself extends approximately 16 miles (26 km) in a north-south direction and 47 miles (76 km) in an east-west direction, and has a mean altitude of 1,500 ft. An extensive basin 150 square miles and with a mean altitude of 950 ft (289 m), forms a large part of the plain. Lake Mentz occupies 8 square miles of the basin. In the north-eastern portion of the Noorsveld, the topography is varied and characterized by rounded hills. Between these hills are numerous valleys, with the main valley deeply incised by the Sundays River.

The geological formations represented in the area are strongly folded, and belong to the Cape System as well as to the Karoo System. The Cape System is represented by the Witteberg Series, and the Karoo System by the Dwyka, Ecca and Beaufort Series, which show occasional intrusive dolerite dykes.

The soils of the Noorsveld are classified as Semi-arid and Desert Types by Van der Merwe (1962). Lithosols are found almost throughout the Noorsveld on the plains, ridges and mountains, and are mainly composed of almost uniformly disintegrated shales, sandstones and mudstones, giving rise to the thin veneer of soils overlying the bedrock. The surface soils have mainly a varying mixture of dark-brown, sandy loam and a dark-brown, sandy-clay-loam layer. The soil pH varies from slightly acid to slightly alkaline. The depth of the soil varies from a few inches to 2 ft (0.6 m), and the ground surface is almost throughout strewn with stone fragments or rubble. Recent alluvial soils, deposited by water, are found in narrow strips along water courses and occur extensively around Lake Mentz. These soils are of great agricultural importance to this area.

The Noorsveld is drained in the form of a dendritic pattern, as is shown by the Sundays River system. On the whole, the drainage of the Noorsveld is well developed.

#### CLIMATE

According to Köppen's classification of world climate (Schulze, 1947) as well as the formulae proposed by Miller (1950), the Noorsveld has a desert climate, which is hot and dry.

The mean daily sunshine duration at Jansenville 1,450 ft (442 m) for the period 1956–1963, varied from 6.9 hours during the day late autumn month, May, to 10 hours during the wet early summer month, December, which indicates the arid character of the region.

Temperature records for Jansenville 1,450 ft (442 m) and Lake Mentz 994 ft (303 m), shows that there is a relatively small seasonal difference in mean temperatures. It also indicates that the values for absolute maximum are higher on the

plains than on the northerly ridge areas, but that the values for mean daily maximum and mean daily minimum almost correspond. The average temperature for Jansenville for the period 1940–1950 at 1400 hours was 25°C (77°F).

Observations on wind direction and wind speed at Jansenville, indicates that the south-easter comprises 60% of the total winds. This is contrary to that of the neighbouring Karoo areas where the predominant wind is from the west. October to March is the windy period, when the south-easter often reaches speeds of 8 m/sec., and the frequency of calms falls below 30%.

The Noorsveld lies in the summer rainfall area of South Africa. The average rainfall per annum for the whole of the Noorsveld during the period 1878–1950 was 256 mm. The peak rainfall month for the whole area is March, while June is generally the driest month. The south-easterly wind is the main rain bearing wind. The rain falling in the Noorsveld is usually of orographical and convectional origin, with the latter being more common during spring and summer. The rains are usually of low intensity. That the rainfall of this region is markedly effected by the mountain ranges in the south and north is shown by the rain-shadow which is created north of the Oudeberg Mountains. Droughts do not occur in any regular pattern, and are generally of low intensity owing to the usually short duration of each. As an ecological factor hail seems to be of some importance in the Noorsveld. Due to its general low altitude, the area is relatively frost-free. Winter fog occurs only during the early mornings in the plains and in the valleys.

#### MAIN ECOLOGICAL REGIONS

During the survey four main ecological regions were recognized in the Noorsveld according to topographical differences, namely river banks, plains, ridges and mountain slopes. Fig. 2 depicts an idealized section (A to B; Fig. 1) in profile through the Noorsveld, which shows the occurrence of the main plant communities as related to the ecological regions. The communities shown in the foreground for each ecological region, are those which are mainly present in the respective areas. Towards the background in the figure, the variation in the communities is depicted.

#### METHODS

The method adopted to make a complete systematic record of the distribution of major plant species over the whole area, was to make observations on abundance at specific survey sites on predetermined routes. Scales of visual estimation were also applied at each survey site to criteria such as height of the dominant components of the various strata, utilization of the vegetation, ground surface condition, and the amount of stone rubble on the ground surface. The geographical boundary of the Noorsveld was also delimited during this survey.

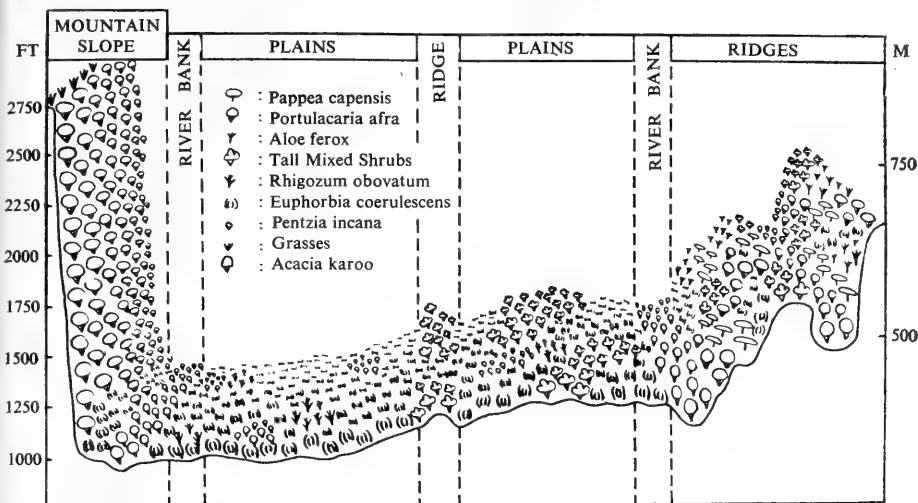


FIG. 2. An idealized profile through the Noorsveld (A to B; Fig. 1) depicting the occurrence of the main plant communities as related to the main ecological regions.

The method used for community classification was to rank the major species, chosen to define a particular community, into a descending order based on their height and aerial cover.

The determination of the structure of the major plant communities involved the collection of quantitative data. Only one survey site was chosen for each community. Owing to the lack of suitable surveying methods applicable to the Noorsveld vegetation, which is difficult to penetrate owing to the height and thorniness of the vegetation, it was necessary to resort to the chain surveying-method (Tidmarsh and Havanga, 1955), which was devised for the measurement of semi-open grasslands and karoo vegetation on rock strewn slopes.

## VEGETATION

The general appearance of the vegetation is dry and xerophilous, which is evidenced by the abundance of the succulent spiny, leafless bush (Brown, Hutchinson, Prain, 1925), *Euphorbia coerulescens* (see Photo 1).

Four vegetational strata can be distinguished in the Noorsveld, viz.

*A-stratum*: The height of the following dominants, mainly small trees, varies between 8 ft and 13 ft (2.5 to 4 m): *Aloe ferox*, *Capparis oleoides*, *Pappea capensis*, and *Schotia speciosa*.

*B-stratum*: The height of the following dominants, mainly tall shrubs, varies between 4 ft and 8 ft (1.2 and 2.5 m): *Grewia robusta*, *Maytenus capitatus*, *M. polyacanthus*, *Lycium austrinum*, *Nymania capensis* and *Portulacaria afra*.

*C-stratum*: The height of the following dominants varies between 1 ft and 5 ft (0.3 to 1.5 m): *Euphorbia coerulescens* and *Rhigozum obovatum*.

*D-stratum*: The height of the following dominants, dwarf shrubs and small grasses, varies between 0.5 ft and 2 ft (0.1 to 0.6 m): *Pentzia incana*, *Aristida congesta* and *A. diffusa*.

Plants less than 0.5 ft (0.1 m) high were omitted.

The vegetation of the Noorsveld could be grouped into the following 8 communities:

1. *Pappea capensis* Community

As shown in Fig. 3, *Pappea capensis* occurs over almost the entire range of the Noorsveld. The present population, which probably represents only a small fraction of the once existing population, exhibits a continuous gradation toward greater abundance with an increase in altitude from the lower plains to the lower mountain slopes. The areas of greatest abundance are situated

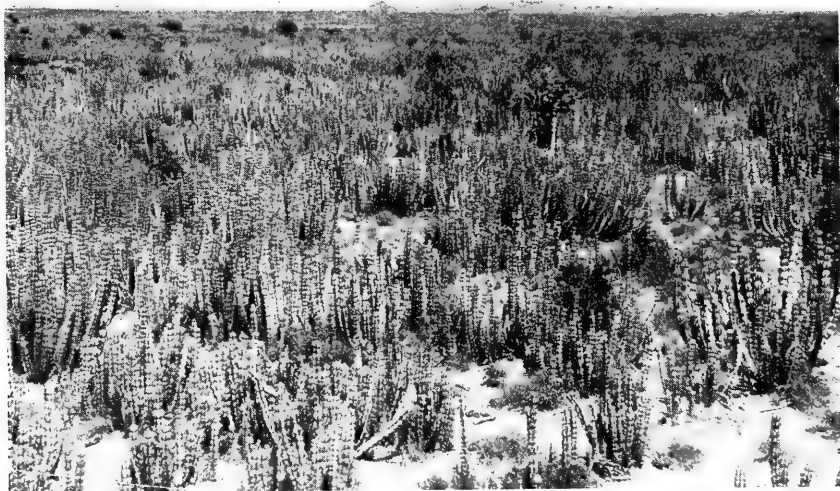


PHOTO 1. A dense stand of *Euphorbia coerulescens* on the lower plains.

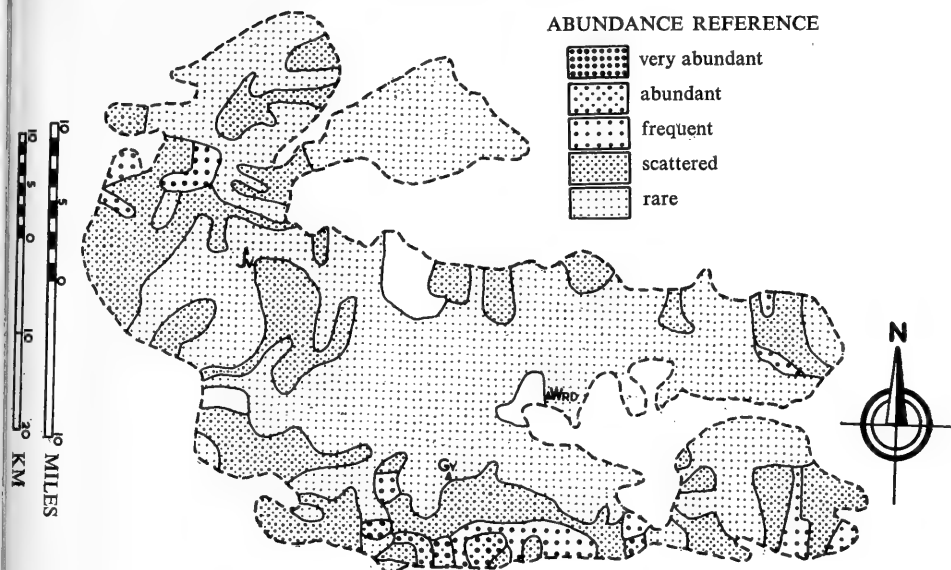


FIG. 3. Abundance of *Pappia capensis* in the Noorsveld.

along the southern boundary of the Noorsveld. From these areas northwards the population decreases gradually into the neighbouring plains.

As shown in Fig. 10, the community is found as isolated patches of limited extent on mountain slopes and ridges. The community is limited mainly to the higher southern and northern areas, where it is most characteristically developed. (See Photo 2). The community extends at its western limits on to isolated ridges, where, however, it is poorly developed.

The community is stratified into four strata. *Pappia capensis* is the dominant species in the upper stratum, and shows an uniformity in height, rarely exceeding 10 ft (3 m). The strata of tall shrubs is less definite, with *Euphorbia coerulescens* more prominent in the form of dense clusters in the C-stratum. The clusters vary in size from 2 ft to 20 ft (0.6 to 6.1 m), and have a rounded to elongated outline as would be viewed from above with no obvious regularity in form. The D-stratum is discontinuous, with patches of bare ground of more than 1 ft (0.3 m) frequent. Grasses such as *Panicum maximum* and *Sporobolus fimbriatus* are present within the *E. coerulescens* clusters. Tufted grasses mostly *Aristida congesta*, *A. diffusa* and *Eragrostis lehmanniana*, with *Pentzia incana*

the more abundant among the dwarf shrubs, were frequently present between the *E. coerulescens* clusters.

## 2. *Portulacaria afra* Community

The isolated patches, shown in Fig. 4, of semi-closed to closed thickets on the northern, western and eastern ridge areas and on the north-western plains, are only a remote indication of the formerly widespread population of *Portulacaria afra* in the Noorsveld.

This community occupies only a small fraction of the total area of the Noorsveld, and is represented mainly on the mountain slopes along the northern and southern boundaries of the Noorsveld, as well as on the north-western plains.

The community itself is stratified into three strata being dominated by the B-stratum with *Portulacaria afra* as the main component. The growth form of *P. afra* is slender and erect, with flexible drooping branches. The plant occurs in clumps, which vary in height from 7.5 ft (2.3 m) in the centre portion, to 1.5 ft (0.4 m) along the periphery; this difference in height is mainly ascribed to pruning by goats. The areas between the clumps are generally much less than the size of a clump, which ranged from 6 ft to 30 ft (1.9 to 9.1 m).



PHOTO 2. A stand of the *Pappea capensis* Community in the background on the higher northern ridges.

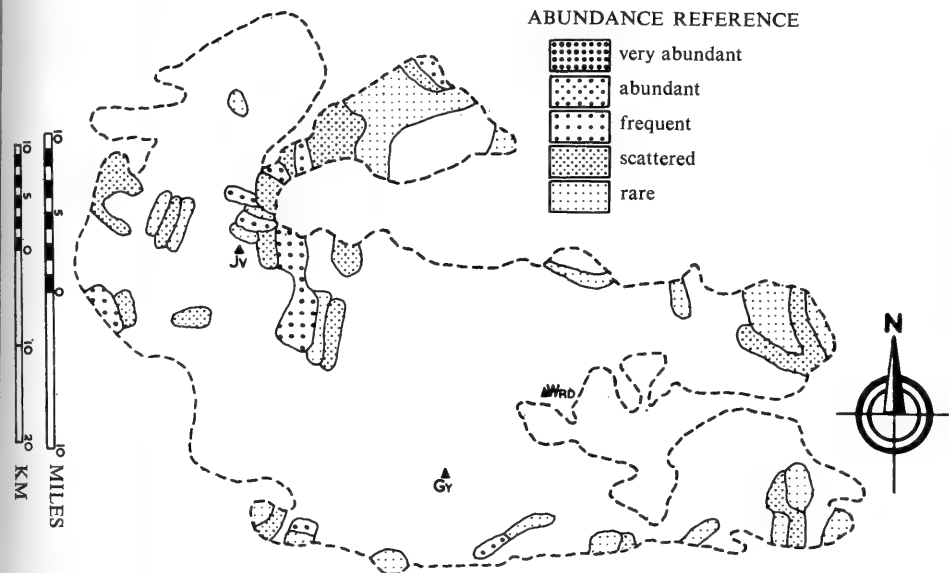


FIG. 4. Abundance of *Portulacaria afra* in the Noorsveld.

The components of the C-stratum are mainly confined to the dense *P. afra* clumps, where they are largely obscured. The height of *Euphorbia coerulescens* varies markedly, averaging 3 ft (0.9 m), but within *P. afra* clumps individual branches may reach as much as 7 ft (2.2 m). Within *P. afra* clumps, the branches of *E. coerulescens* are spread out separately, but when they occur outside these sheltered places, the branches are arranged in clusters and are dominant over small areas where the B-stratum is broken. The D-stratum is ill defined by a few dwarf shrubs mainly *Pentzia incana* and shade loving grasses such as *Panicum maximum* and *P. deustum*.

### 3. Tall Mixed Shrub Community

The following tall shrubs, which vary in height from 5 ft to 8 ft. (1.6 to 2.5 m), form the main components of this community in the Noorsveld:

Maytenus capitatus	Maytenus polyacanthus
Lycium austrinum	Nymania capensis
Grewia robusta	Carissa haematocarpa
Euclea undulata	

The distribution pattern of the shrubs is related to relief features because

rocky ridges seem congenial to the establishment of these shrubs. On the low lying plains in the Noorsveld these shrubs are sparsely scattered, as shown in Fig. 5.

This community is well represented over the Noorsveld, and is also most frequently found on the northern ridges.

The community is stratified into three strata with the B-stratum well represented by tall shrubs. There is a tendency for the shrubs in the *Euphorbia coerulescens* clusters to be taller than those outside. The C-stratum is very distinct in this community and is represented by *E. coerulescens* and *Rhigozum obovatum*. The former species predominates, with the clusters varying in size from 2 ft to 16 ft (0.7 to 4.8 m). The D-Stratum is represented mainly by *Pentzia incana*, *Nestlera humilis*, and *Selago triquetra* between the *E. coerulescens* clusters, but *Panicum maximum*, *Cenchrus ciliaris* and *Digitaria argyrograpta* are found sporadically within the *E. coerulescens* clusters.

#### 4. *Aloe ferox* Community

*Aloe ferox* is represented only along the northern rocky ridges, generally with low abundance, although on small areas very dense stands may be found, as shown in Fig. 6.

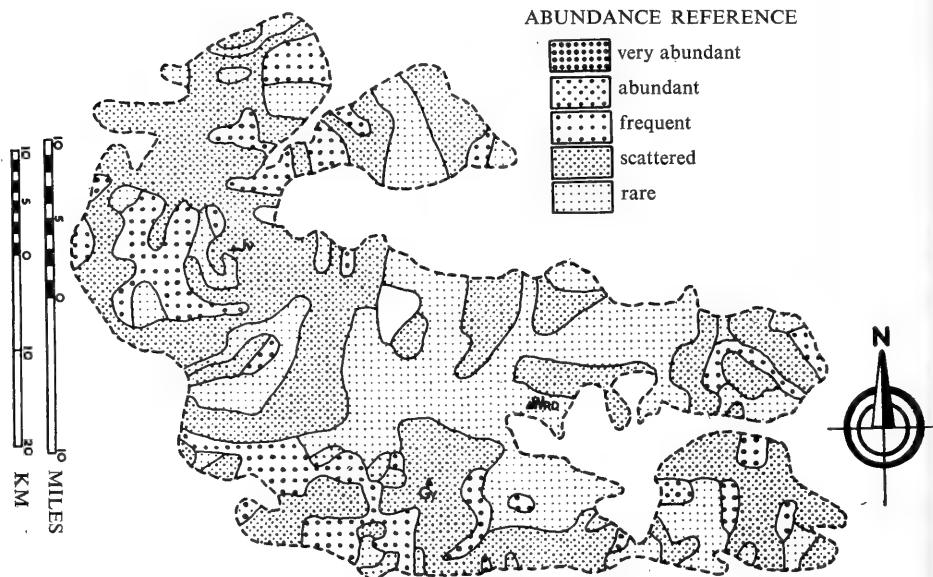
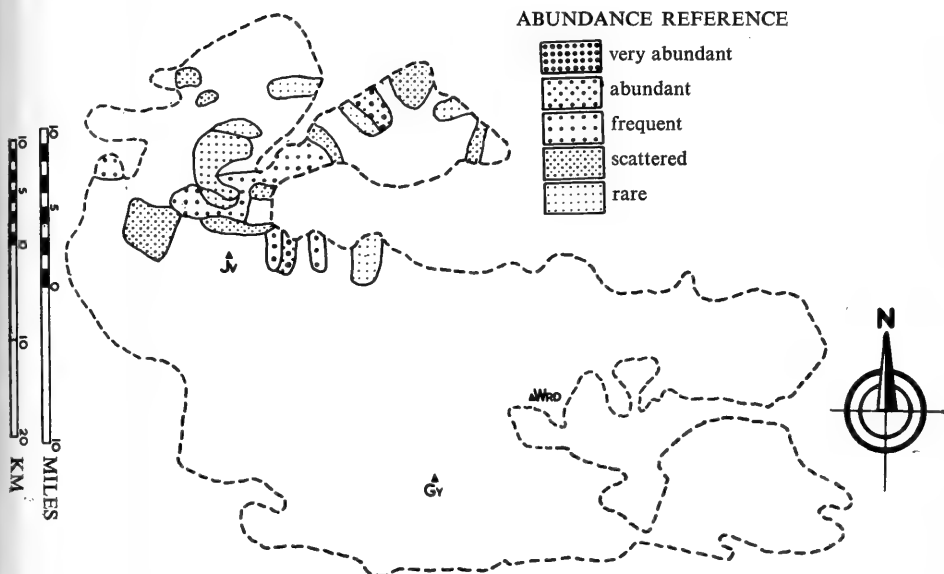


FIG. 5. Abundance of Tall Mixed Shrubs in the Noorsveld.



FIG. 6. Abundance of *Aloe ferox* in the Noorsveld.

The community is present in a few isolated patches of limited extent, confined to northern rocky ridges and dolerite dykes.

The community is stratified into four strata with the general structure that of relatively open upper strata dominated by *A. ferox*, with a dense D-stratum, represented by *Pentzia incana*, *Aristida diffusa* and *Eragrostis obtusa*, between the *Euphorbia coerulescens* clusters (see Photo 3).

##### 5. *Rhigozum obovatum* Community

*Rhigozum obovatum* is distributed almost over the entire Noorsveld, as shown in Fig. 7. The areas of high abundance occur on the plains, with the highest abundance being reached on an area south-west of Lake Mentz.

This community is not very common in the Noorsveld and becomes generally most characteristically developed on plain areas.

Small trees and tall shrubs are absent in this community which is therefore only stratified into two strata. The general structure differs not much from that of the *Euphorbia coerulescens* Community but on the whole it is more open, with only a small number of species present.

The two major components of the C-stratum, *R. obovatum* and *E. coerulescens*, almost shares dominance, with *R. obovatum*, reaching 3 ft (0.9 m) in height, being the more prominent. The D-stratum is mainly represented by scattered shrubby members of *Lycium* sp. and *Pentzia incana*. Wide stretches of bare soil are present.

6. *Euphorbia coerulescens* Community

The main body of the *Euphorbia coerulescens* population occupies the large low lying plains between the Oudeberg Mountains in the north and the Klein Winterberg, Klein Winterhoek and Suurberg Mountains in the south, extending in a tongue into the higher northern undulating country, as shown in Fig. 8. The distribution centre is situated almost on the southern boundary, near the junction of the Klein Winterberg and Klein Winterhoek mountain ranges. From this point the abundance of the population declines sharply in a most complex, discontinuous pattern, with no evident regularity.

The irregular distribution pattern of *E. coerulescens*, with a general increase in abundance towards the centre of the Noorsveld, and the detached relict



PHOTO 3. A stand of the *Aloe ferox* Community on the north-western ridges.

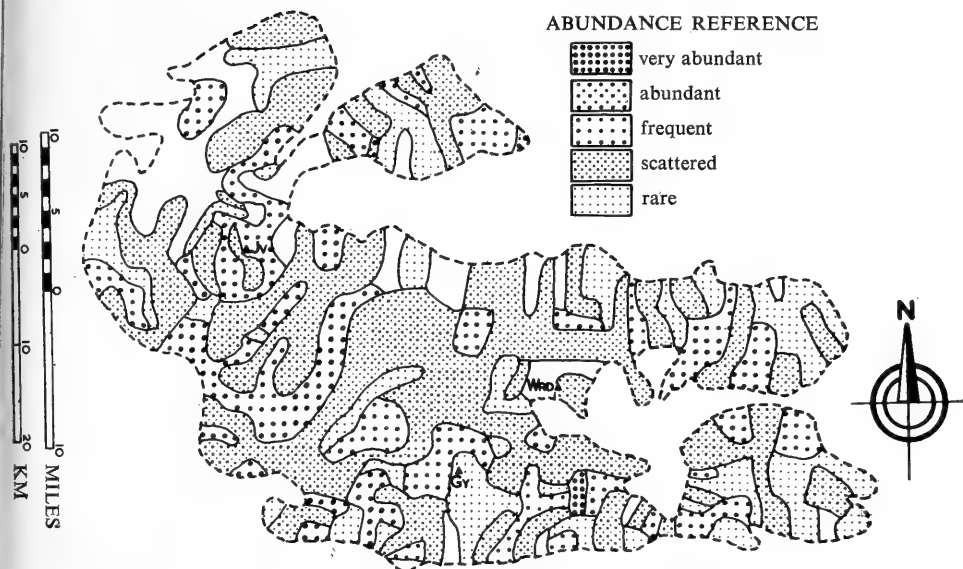


FIG. 7. Abundance of *Rhigozum obovatum* in the Noorsveld.

colonies of *E. coerulescens* in the neighbourhood of the northern, eastern and southern boundaries, suggest that the Noorsveld as such could be considered as a contracting area. There is also a general failure in the reproductive capacity of *E. coerulescens*, seed germination having almost ceased probably because of the shallow, poorly developed soil cover, while vegetative reproduction is checked to a large extent by grazing. The overall decrease in abundance of *E. coerulescens* toward the eastern boundary indicates that these parts experience the greatest amount of contraction.

That topographical features influence the shape of the Noorsveld, is shown by the relatively continuous boundary along the mountain ranges in the north and south. The possibility of further extension of the Noorsveld in these directions is doubtful because it appears that these ranges act as physiographic barriers. Extension to the east and west is probably checked by a biotic barrier. Grazing and man seems to constitute mainly this biotic barrier, because any successful establishment of *E. coerulescens* outside its present distribution, is prevented.

This characteristic and distinct community, is the most widespread com-

munity in the Noorsveld. It is most characteristically developed on the lower plains (See Photo 1).

The community is stratified into the two lower strata with the C-stratum very well represented by *E. coerulescens*. The branches of *E. coerulescens* forms dense clusters of uniform height of 2.7 ft (0.8 m), giving a relatively smooth appearance to the stratum. The D-stratum is well represented by the dwarf shrub, *Pentzia incana*, which is dominant between the *E. coerulescens* clusters, interspersed with occasional tufts of the grasses *Eragrostis obtusa*, *Aristida diffusa* and *A. congesta*.

#### 7. *Pentzia incana* Community

As shown in Fig. 9, this dwarf shrub, *Pentzia incana*, reaches greater abundance on the lower plains than along the mountain slopes and on the higher northern ridges.

The community is found only as a few small patches which are limited to the lower plains.

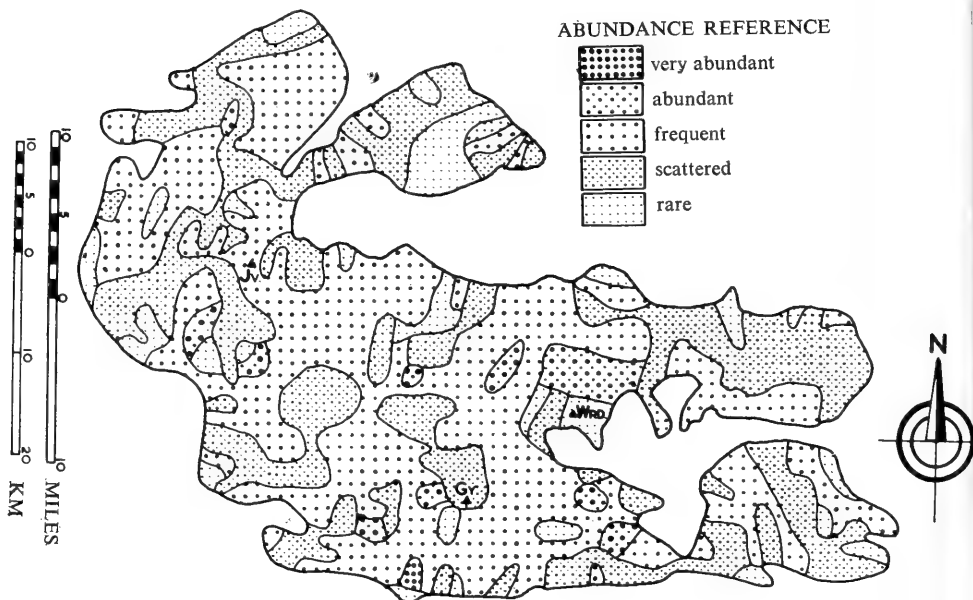


FIG. 8. Abundance of *Euphorbia coerulescens* in the Noorsveld.

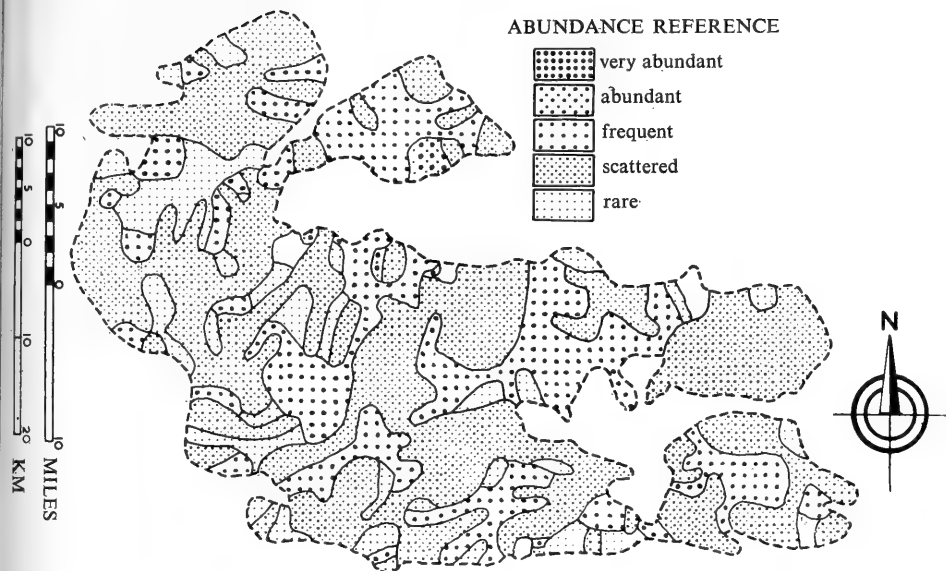


FIG. 9. Abundance of *Pentzia incana* in the Noorsveld.

Only the D-stratum is present. A few scattered branches of *Euphorbia coerulescens* are present which are too irregularly distributed to constitute a definite C-stratum. The D-stratum is dominated by *Pentzia incana*, which occurs in groups, placed at varying distances from one another. Between these groups *Aristida diffusa*, *A. congesta*, and dwarf shrubs of *Lycium sp.* attain local dominance. Large bare soil patches are present.

#### 8. *Acacia karoo* Community

*Acacia karoo* is found mainly along the river courses in the Noorsveld.

This community frequently forms a very striking contrast to the surrounding vegetation. Where fully developed the community is two-layered, with *A. karoo* very abundant, forming a closed canopy, ranging from 16 ft to 33 ft (5 to 10 m) in height. The constituents of the field layer are mainly *Panicum maximum* and *Cenchrus ciliaris*, forming local patches with bare ground between the patches.

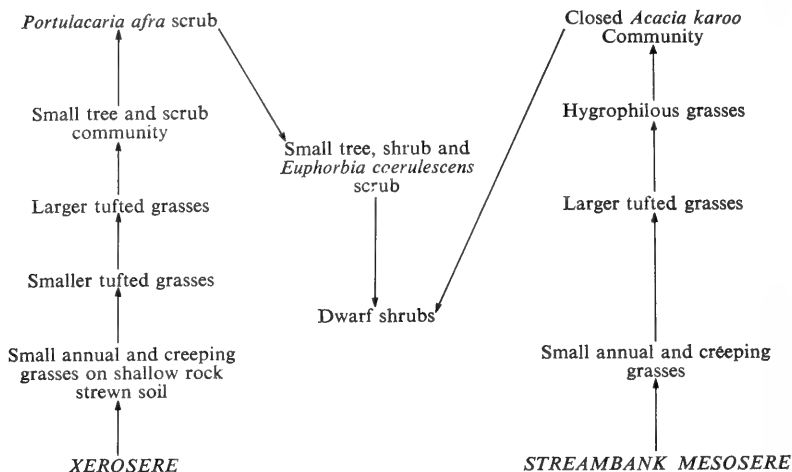
#### *Relationships of the vegetation*

The present vegetation of the Noorsveld is of a secondary nature. Man has been directly or indirectly responsible for the change in the vegetation. Table 1

is a generalized scheme showing the relationships of the vegetation in the Noorsveld.

TABLE I

A generalized scheme showing the relationships of the vegetation in the Noorsveld.



Evidence, which is largely provided by the existing vegetation, suggests that the ultimate vegetational development in the Noorsveld is a dense scrub, dominated by *Portulacaria afra*. The relict plants of *P. afra*, now protected from grazing by *Euphorbia coerulescens* clusters (see Photo 4) and which are found throughout the Noorsveld, and the isolated patches of the *P. afra* Community, indicates a former widespread occurrence of the *P. afra* scrub climax.

With the intervention of man during modern times, a rapid change of the *P. afra* scrub started. The vegetational development is deflected by grazing into a new course.

Severe grazing, checking any re-growth, results in the gradual destruction of *P. afra*. *E. coerulescens* takes advantage of the new conditions for invasion and increase rapidly in number by the centrifugal migration from rootstocks, which produces new branches that form clusters. The small trees and shrubs increase in height but not in number probably due to the elimination of competition afforded by the former well developed *P. afra* layer and with grazing checking any growth of seedlings. Grasses such as *Digitaria argyrogypsa*, *Heteropogon contortus*, *Cenchrus ciliaris*, *Themeda triandra*, *Setaria neglecta* and *Panicum maximum*, which formerly formed a large component of the *P. afra*



PHOTO 4. A relict plant of *Portulacaria afra* which is now protected by a *Euphorbia coerulescens* cluster.

scrub, are now protected by the *E. coerulescens* clusters. These clusters provide improved habitat conditions for the growth of these grasses because the decomposition and accumulation of dead plant parts add organic matter to the soil, thereby improving its structure.

Under continuous grazing, *P. afra* is eventually exterminated. *E. coerulescens* forms a very dense stand, which is almost impenetrable because the individual clusters link up with each other. This stage is considered to be fully developed under the action of the disturbing factors.

The further alteration of the vegetation is brought about by the combined action of man and the grazing animal. *E. coerulescens* branches are cut over large areas for fodder, thereby exposing the palatable shrubs and grasses, sheltered within the clusters, to grazing (see Photo 5). Small trees and tall shrubs, already grazed up to the browse line, are felled for fodder, firewood and fencing poles. Under these conditions soil erosion becomes accelerated. Grasses such as *Aristida diffusa*, *A. congesta* and *Cynodon incompletus*, and dwarf shrubs gradually increase. With continued grazing, species are forced out in order of their palatability.

The further development of the vegetation in this deflectional process, is largely determined by local habitat conditions.

Thus the effects of man on the vegetation of the Noorsveld, has given rise to an intricate vegetation patterning, consisting of variety of seres of deflection. The degree of deflection in the various seres, is largely related to the degree of past disturbance and not so much as to any particular environmental factor.

In conclusion, the Noorsveld vegetation can be considered to have been predominantly a *Portulacaria afra* Scrub, which has been converted into what can be described as a Small Tree, Shrub and Succulent Steppe (this terminology was taken, with modification, from Boughey, 1957).

#### *General Aspects*

The Noorsveld has a higher carrying capacity than the Veld Types adjacent to it, due to the presence of *Euphorbia coerulescens*. The presence of a large number of small farming units, some less than 400 morgen, is an indication

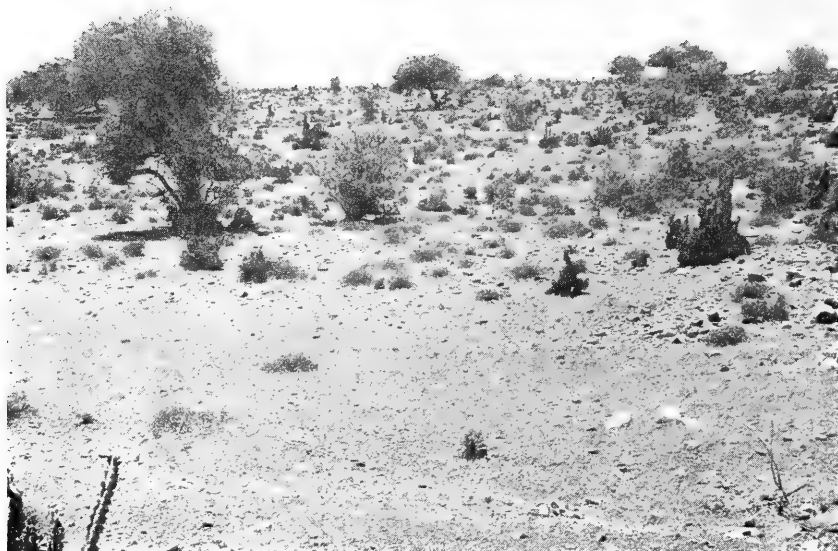


PHOTO 5. A severely grazed and eroded area. A few *Euphorbia coerulescens* plants are widely scattered.



of the high exploitation potential of this region. To implement higher stocking rates, some unique farming practises are being employed.

The farmers are fully aware of the value of *E. coerulescens* as fodder for stock. *E. coerulescens*, due to its drought resistant properties, also provides sufficient fodder for stock during periods of drought. The branches are not normally eaten by stock, except the soft young apical joints and shoots. Chopped up branches are, however, palatable to stock. The branches are cut into segments of 1 to 12 inches (2.5 to 30 cm) are left on the ground, or are removed to a feeding lot. The chopping of the branches is in some cases carried out by means of a machine, or by hand by means of a long-bladed panga (see Photo 6). The stock relish the chopped segments sometimes immediately, depending on the size of the chopped segments, or more often when the segments have dried out for a day or two. The stock acquire the trick of scraping off the thorns of the branches with their hooves or horns, before eating the chopped segments.



PHOTO 6. The two methods being used by farmers in the Noorsveld to chop *Euphorbia coerulescens* into slices.

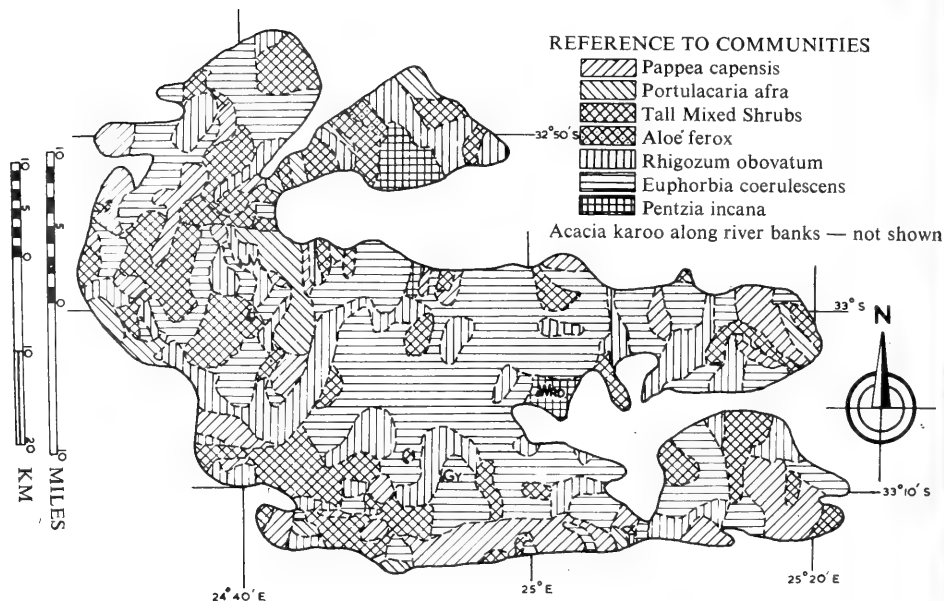


FIG. 10. Vegetation Map of the Noorsveld.

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# THREE NEW SPECIES OF FERNS FROM SOUTHERN AFRICA†

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## ABSTRACT

*Asplenium mossambicense* Schelpe, *Elaphoglossum drakensbergense* Schelpe and *Pellaea dolomiticola* Schelpe are described as new species from Southern Africa.

During the course of preparing a monograph of the Pteridophyta of Southern Africa, south of the Zambesi and Cunene rivers, a few new species have come to light. Most of the new taxa from south east tropical Africa were published recently (*Bol. Soc. Brot.*, sér. 2a, 41 : 203–217 (1967)) but three further new species from Southern Africa warrant publication.

*Asplenium mossambicense* Schelpe sp. nov. ex affinitate *A. christii* a qua differt pinnis fertilis majoribus non ad apicem gradatim decrescentibus nec distantioribus.

Rhizoma erectum c. 5 mm diam, paleis atrofusis concoloribus clathratis lanceolatis acuminatis integris 3–4 mm longis. Frondes caespitosi arcuati, tenuiter coriacei dimorphi gemmiferi. Stipes impolitus griseo-viridis usque ad 42·5 cm longus, primus paleis fuscis sparsis obsitis, demum subglabrescens. Lamina imparipinnata in ambitu oblongo-lanceolatis acutis usque ad 37 cm longa et 15 cm lata, pinnis infimis non reductis. Rachis griseoviridis sparsim paleis minutis atrofusis attenuatis obsitis. Pinna usque ad 8-jugatae oblongae acutae vel obtusae petiolatae inaequaliter cuneatae serratae glabrae. Sori lineares usque ad 1·7 cm longi leviter curvatae; indusium c. 1 mm latum membranaceum integrum.

TYPE: Mozambique, Manica e Sofala, Gorongosa Mtn, 7. vii. 1955, Schelpe 5593 (Holotype BOL; isotype BM).

RHODESIA: Chirinda district, 24.x.1947, Wild 2203 (EAH, K, SRGH).

MOZAMBIQUE: Serra de Gorongosa, Mt. Nhandore, 6.v.1964, Torre & Paiva 12291 (LISC).

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† Accepted for publication 30th May, 1968.



PLATE 1.  
Holotype of *Asplenium mossambicense* Schelpe. ( $\times c. \frac{2}{3}$ )

Rhizome erect c. 5 mm diam, with dark brown concolorous clathrate lanceolate acuminate entire rhizome scales 3—4 mm long. Fronds tufted, arched, thinly coriaceous, dimorphous gemmiferous. Stipe dull greyish green up to 42.5 cm long, at first sparsely set with brown scales, later becoming glabrous with age. Lamina imparipinnate, oblong lanceolate acute in outline, up to 37 cm long and 15 cm broad, the lowest pinnae not reduced. Rachis greyish green sparsely set with minute dark brown attenuate scales. Pinnae up to 8-jugate, oblong, acute to obtuse, petiolate unequally cuneate, serrate glabrous. Sori linear, somewhat curved, up to 1.7 cm. long; indusium c. 1 mm broad membranaceous entire.

*A. mossambicense* appears to be endemic to southern Mozambique and the Maseru district of Rhodesia, where it occurs on deeply shaded boulders in forest at elevations from 3,700 ft. to 4,000 ft. It is larger but similar to *A. christii* Hieron., which occurs through east tropical Africa from Zululand to Kenya, but the pinnae are markedly larger, and those of the fertile fronds are not so distant nor so gradually decrescent towards the apex as they are in *A. christii*.

***Elaphoglossum drakensbergense* Schelpe sp. nov.**

Rhizoma repens c. 1 mm diam usque ad 14.5 cm longum, frondibus c. 5 mm distantibus, paleis castaneis anguste lanceolatis serrulatis aristatis usque ad 4 mm longis et 0.4 mm latis. Stipes usque ad 14 cm longus fuscus, paleis squarrosis, pallide fuscis, lanceolatis attenuatis serrulatis c. 2 mm longis, obsitis. Lamina sterilis membranacea usque ad 6.5 cm longa et 1.6 cm lata anguste oblonga acuta, ad basim late cuneata, paleis pallide fuscis lanceolatis serrulatis usque ad 1 mm longis, plerumque secus costam et marginem obsitis; venis c. 1 mm distantibus. Lamina fertilis usque ad 3.2 cm longa et 1 cm lata, anguste oblonga vel elliptica, acuta vel obtusa, ad basim late cuneata vel truncata, vix decrescentis supra paleis c. 1 mm longis obsitis.

TYPE: Natal, Estcourt district, Drakensberg, Injasuti area, weathered rock faces overhung by rock, S. aspect, 6,500—7,500 ft. vii. 1956. *Esterhuysen* 26052 (Holotype BOL; isotype K).

NATAL: Bergville district, Drakensberg, Mweni area, 8,000 ft., vii. 1953. *Esterhuysen* 21667 (BOL); Drakensberg, Mont-aux-Sources area, Sentinel, sheltered crevice, N.W. aspect, 9,500 ft., vii. 1947, *Schelpe* s.n. (BOL); Estcourt district, source of Mooi R. (Drakensberg), 7,000—7,500 ft. *Bell* s.n. (in Herb. Hooker) (K).

Rhizome long creeping c. 1 mm diam, up to 14.5 cm long, with fronds spaced c. 5 mm apart and with castaneous narrowly lanceolate attenuate serrulate rhizome scales up to 4 mm long and 0.4 mm broad, with a long hair point. Stipe up to 14 cm long brown (with a darker phyllopodium c. 5 mm long) set with squarrose pale brown lanceolate attenuate serrulate scales up to 2 mm long.

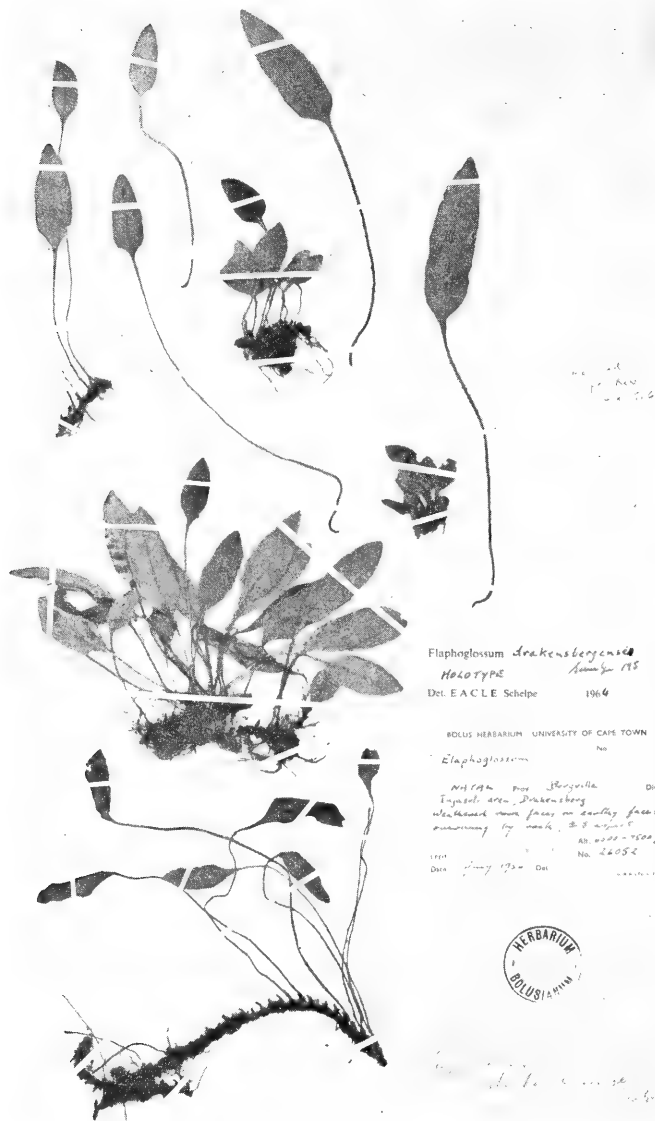


PLATE 2.

Holotype of *Elaphoglossum drakensbergense* Schelpe. ( $\times c. \frac{3}{2}$ )

Sterile lamina membranaceous up to 6.5 cm long and 1.6 cm broad narrowly oblong acute, base broadly cuneate and set with pale brown lanceolate serrulate scales up to 1 mm long mostly along the midrib and margin but also on the lamina, veins c. 1 mm apart. Fertile lamina up to 3.2 cm long and 1 cm broad narrowly oblong to elliptic, acute to rounded, base broadly cuneate to truncate, hardly decrescent, the upper surface set with scales c. 1 mm long.

*E. drakensbergense* is apparently endemic to the high Drakensberg between 7,000 and 9,500 ft. altitude. It is superficially similar to *E. subcinnamomeum* (Christ) Hieron. of the high tropical African mountains in its slender creeping rhizome with dark rhizome scales, but the laminar scales in *E. drakensbergense* are serrulate, not ciliate, and the fronds are smaller and thinner in texture than in *E. subcinnamomeum*.

***Pellaea dolomiticola* Schelpe sp. nov.**

Rhizoma suberectum c. 4 mm diam, paleis pallide fuscis anguste lanceolatis acuminatis usque ad 4 mm longis. Frondes caespitosi, erecti vel patuli, tenuiter coriacei. Stipes usque ad 7 cm longus castaneus, leviter sulcatus, paleis pallide fuscis late vel anguste lanceolatis integris vel minute serrulatis usque ad 4 mm longis et 1 mm latis obsitis. Lamina usque ad 8.5 cm longa et 4 cm lata, in ambitu late elliptica vel rotunda, bipinnata vel tripinnatifida, pinnis basalibus reductis. Rachis castanea, paleis pallide fuscis lanceolatis acuminatis serrulatis usque ad 3 cm longis dense vel sparsim obsitis. Pinnae 3—6-jugatae, in ambitu oblongae acutae, usque ad 2 cm longae et 1.2 cm latae, segmentis pinnarum plerumque anguste oblongis acutis, raro late oblongis obtusis, supra glabris, infra secus costam paleis pallide fuscis serrulatis dense obsitis, venis obscuris. Sori marginales lineares; indusium erosum membranaceum.

TYPE: Cape Province, Vryburg division, Tiger Kloof, 2. iv. 1956, locally common in north and south aspect limestone crevices, 4,100 ft., *Schelpe* 5885 (Holotype BOL; isotype BM).

CAPE PROVINCE: Kimberley division, 32 miles east from Griquatown, *Schelpe* 5881 (BOL).

TRANSSVAAL: Krugersdorp district, "Waterval 74", 2 miles north-west of Krugersdorp, *Mogg* 22999 (BOL). Lydenburg district, road from Ohrigstad to Burgersfort, about 6 miles from Burgersfort, *Braithwaite* 244 (BOL).

Rhizome suberect c. 4 mm diam with pale brown entire narrowly lanceolate acuminate rhizome scales up to 4 mm long. Fronds tufted, erect to spreading, thinly coriaceous. Stipe castaneous, up to 7 cm long, shallowly sulcate, thinly to densely set with pale brown, broadly to narrowly lanceolate, acuminate, entire to minutely serrulate scales up to 4 mm long and 1 mm broad. Lamina broadly elliptic to rotund in outline, bipinnate to tripinnatifid, up to 8.5 cm long and 4 cm broad, with the lowest pinnae reduced. Rachis castaneous, densely to thinly



PLATE 3.  
Holotype of *Pellaea dolomiticola* Schelpe. ( $\times c. \frac{7}{8}$ )



set with pale brown lanceolate acuminate serrulate scales up to 3 cm long. Pinnae 3—6-jugate, oblong acute in outline, up to 2 cm long and 1·2 cm broad; pinna segments usually narrowly oblong acute, rarely broadly oblong obtuse, glabrous above, densely set with pale brown serrulate scales along the costa, veins obscure. Sori marginal linear; indusium membranous erose.

*P. dolomiticola* belongs to the *P. viridis* group of species with non-articulated terminal segments, but is easily distinguished from other African members of this group by the copious pale brown scales on the stipes, rachises and under-surfaces of the costa. *P. dolomiticola* appears to be confined to crevices in dolomitic limestone outcrops from the Northern Cape Province through the southern Transvaal, at altitudes from 3,500 ft. to 5,600 ft.



# SLOANE MANUSCRIPT 5286; AN IMPORTANT SOURCE FOR DECADE 9, 'HERBARIUM CAPENSE' OF PETIVER'S GAZOPHYLACIUM NATURAE AND ARTIS†

PHYLLIS I. EDWARDS

(*British Museum [Natural History]*)

James Petiver (1663 or 4—1718) built one of the most extensive museums of natural history curiosities of the Sloane period. His apothecary shop in Aldersgate was familiar to shipmasters, merchants, planters, surgeons, consuls, and many others whose livelihood took them abroad. In 1695, the year he was elected a Fellow of the Royal Society, he began the systematic description of plants, animals and fossils in his Museum.

The caption to Decade 9 of Petiver's *Gazophylacium* reads: 'Figures of one hundred elegant plants, all growing about the Cape of Good Hope and copied from original paintings taken from the living plants, viz, those which the State of Amsterdam presented to the Right Reverend the Bishop of London (Compton) when his Lordship was at the Congress there in A.D. 1691, and concludes 'with above fifty others painted from growing plants lately purchased from the Cape'.

A set of drawings in the Department of Botany, British Museum (Natural History) Banksian Manuscript No. 88 has been considered to be the collection Petiver purchased from the Cape. This collection (Dryander, *Cat. Bibl. Banks*, Vol. 3, 178 and British Museum (Nat. Hist.) *Catalogue*, Vol. 4, 1558) is however merely poor copies of 73 drawings in the collection of drawings of Cape plants which form Sloane Manuscript 5286 in the British Museum. This Sloane Manuscript has been considered by some to have been the collection of Cape drawings

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† Accepted for publication 1st February, 1968.

given to Bishop Compton in 1691 although evidence in the text to Decade 9 of Petiver's *Gazophylacium* disproves this assumption. In the caption to Tab. 90, fig. 9 Petiver states 'I am obliged . . . of the greatest part of the paintings in this Decade which he (Dr. Martin Dolneus) procured to be drawn on the spot from original plants growing luxuriently wild about that fertile Promontory the Cape of Good Hope'. Sloane Manuscript 3336 f. 13 contains a draft of a letter from Petiver dated 10th December 1707, to Bishop Compton in which he states "I have lately purchased a very curious collection of about 80 paintings of Cape plants each superbly done on large Imperial paper, most of them altogether new and among them are many very amazing bulbs, these I shall be proud to show his Lordship". This collection, acquired through Dolneus, is in fact the source for 74 out of the 100 engravings in the *Herbarium Capense*. Petiver further states in the caption to Tab. 87, fig. 7 'This and the next being very elegant and peculiar plants I have presumed to hand down to posterity under the patronage of his Lordship the Bishop of London . . . being highly obliged to him for the Copies\* of them from his paintings, which he pleased lately to send.' These two engravings (Tab. 87, figs. 7 & 8) are among the 26 engravings for which no original drawings have, so far, been traced in Great Britain. The plants represented in these 26 engravings were among those seen on the expedition of Simon Van der Stel (1639–1712) to Namaqualand in 1685–6 and drawn (there is still some doubt about this, Smith 1952) by Hendrik Claudius. Sets of drawings relating to his expedition are in the South African Museum, South African Public Library, Africana Museum, Johannesburg and Trinity College, Dublin. Not all these sets are alike, each contains a different collection of drawings.

The set in Dublin is included in Fagel (1765–1838) Manuscript 984, which is considered by Waterhouse (1932) to be the official report made by Simon Van der Stel to the Dutch East India Company which was removed from their archives about 1691 or 1692. Petiver states in the caption to Tab. 85, fig. 2 that this engraving was made from the first drawing in Bishop Compton's Collection; this is also the first drawing in the Fagel Manuscript. Barnard (1947) uses the abbreviation T.C.D. when referring to the Fagel collection of drawings and I propose to follow him here. The numbers of the copies of the T.C.D. drawings that correspond to the engravings in the *Herbarium Capense* are given in Table 1.

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\* Sloane Manuscript 5286 is entitled "A Volume of Plants growing about the Cape of Good Hope among which are the Copies of the original paintings which the State of Amsterdam presented to Dr. Compton, Bishop of London when he was at the Congress there in 1691". They are figured for the most part in Mr. Petiver's *Gazophylacium*. The copies of Bishop Compton's drawings are not included as stated above.

TABLE 1.

T.C.D.	853	Tab.	81	Fig.	8
	831	"	82	"	4
	803	"	83	"	7
	863			"	8
	787			"	10
	813			"	11
	841	"	84	"	2
	825			"	4
	785	"	85	"	2
	839			"	3
	849	"	87	"	6
	789			"	7
	795			"	8
	799	"	87	"	9
	823			"	10
	847			"	11
	833			"	12

Further copies of T.C.D. drawings occur on the following plates of an earlier part of the *Gazophylacium*, in Decade 6, Table 2.

TABLE 2.

T.C.D.	855	Tab.	57	Fig.	1
	819			"	4
	809			"	5
	817			"	6
	793			"	7
	815	"	58	"	1
	829			"	2
	835			"	3
	859			"	4

Although Petiver mentions, in the text to Decade 9 that the Bishop only provided him with copies of drawings, he does quite clearly state in the heading to this Decade that the engravings were made from the Bishop's and his own collection of Cape drawings. Compton's collection must therefore have consisted of or included a set of Claudius Namaqualand drawings.

There are 92 folios in Sloane Manuscript 5286. All, except the first folio, have but one drawing. On the first folio are mounted two sheets, containing together, seven small drawings. For the purposes of numbering, these two sheets have been considered to form folios 1 and 2. Engravings of these drawings occur in Decade 7/8, Tab. 77 fig. 3, 9 and 10 and Tab. 78 fig. 2, 3, 9 and 10. They represent different kinds of 'fig. marigold' which Petiver states in his text 'Mr. Gardner of the Temple Garden gave me in flower about the beginning of June 1706'. These drawings would therefore have been made in London and not at

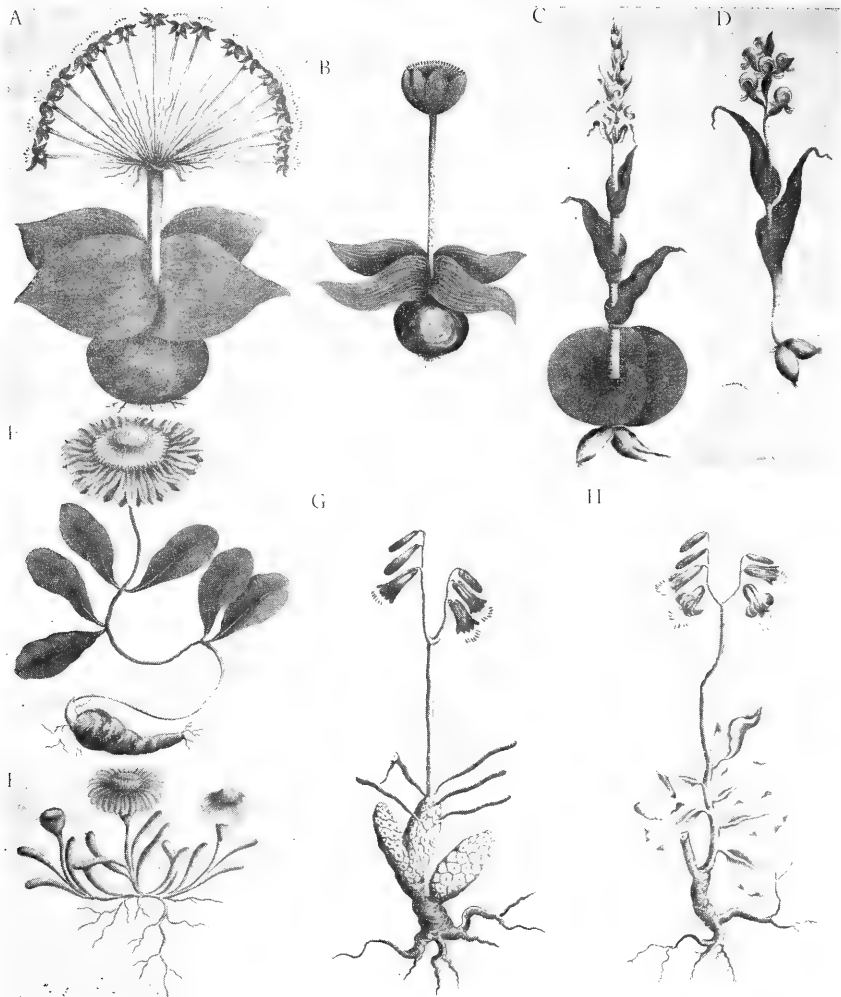
the Cape like the rest of the collection. The Temple Garden, lying between Fleet Street and the Embankment, is still in existence. It is maintained for the pleasure of the inhabitants of chambers in the Inner Temple. Some account of the garden, which in Petiver's day was in fact three separate gardens; The Great Garden, the Benchers' Garden and the Privy Garden is given in Williamson (1925). Petiver's reference to it indicates it was one of the gardens in London where new introductions from overseas were being cultivated. The drawings on folio 3—92 are all by the same artist. Although they are by a competent artist they do not show the same degree of botanical accuracy as shown in the sets of drawings in South African Institutions; in Dublin and the set that is in the British Museum (Natural History). All but eight drawings in the Sloane Manuscript bear a reference to the *Gazophylacium* Tab., Fig. and Catalogue number and also have as a heading, the Latin name of the plant. These annotations are not in Petiver's hand. They must have been added after 1764, because the Catalogue number was not given in the first edition of the *Gazophylacium* but was inserted in the edition of Petiver's entire works published in 1764. Some of the plants depicted are represented in the other collections mentioned above but there is no other set like it or it would appear, by the same artist.

There were obviously drawings of some plants in both the Petiver and Compton collections. Petiver would appear to have copied his own set: for example, three of the Aloe illustrations Tab. 88 Figs. 1—3 are, as Reynolds (1950) points out, different from all the other representations of these particular plants. The fourth Aloe figure Tab. 89, fig. 9 was clearly copied from Plukenet's engraving Tab. 127 in Vol. 1 of his *Phytographia*, 1691.

I wish to gratefully acknowledge the very kind assistance of Prof. H. B. Rycroft of the National Botanic Gardens of South Africa at Kirstenbosch and to thank Miss W. F. Barker, Curator of the Compton Herbarium for providing the determinations of the plants illustrated in Petiver's *Gazophylacium*. I also wish to thank the Department of Manuscripts at the British Museum for permission to have the drawings photographed and some reproduced in this paper.

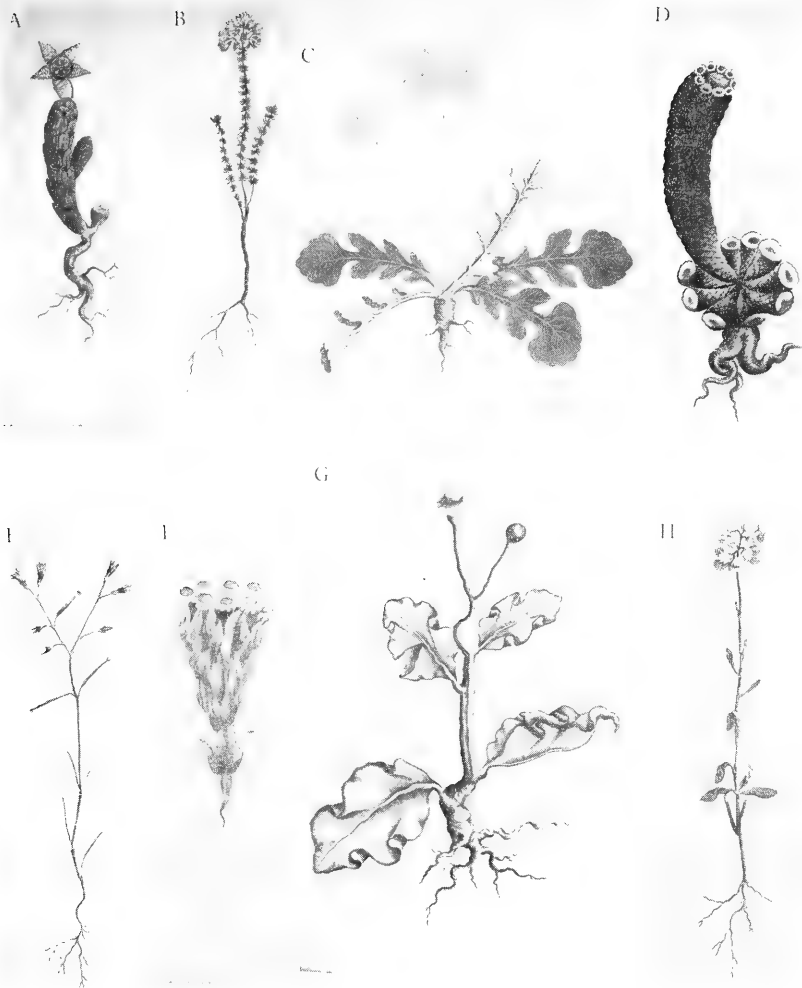


- PLATE 1A. *Spartium capense luteum foliis capillaceis*. *Pet. Gaz.* Tab. 83 fig. 3.  
*Lebeckia simsiana* E & Z (Leguminosae) Folio 30
- B. *Sisyrinchium capense spicatum petalis multifidis*. *Pet. Gaz.* Tab. 87 fig. 5.  
*Wurmbea spicata* (Burm.) Dur. (Liliaceae) Folio 82
- C. *Spartium capense flore coeruleo*. *Pet. Gaz.* Tab. 83 fig. 2.  
*Aspalathus microphylla* DC? (Leguminosae) Folio 31
- D. *Geranium capense frutescens aceris folio*. *Pet. Gaz.* Tab. 84 fig. 5.  
*Pelargonium angulosum* Ait. (Geraniaceae) Folio 43
- E. *Geranium capense frutescens saniculae folio*. *Pet. Gaz.* Tab. 84 fig. 7.  
*Pelargonium* sp. (Geraniaceae) Folio 40
- F. *Erica capensis carneis urceolatis staminibus rubris*. *Pet. Gaz.* Tab. 90 fig. 7.  
*Erica* sp.? (Ericaceae) Folio 80
- G. *Geranium capense cicutaria folio luteum*. *Pet. Gaz.* Tab. 84 fig. 10.  
*Pelargonium triste* (L) Ait. (Geraniaceae) Folio 42
- H. *Geranium myrrhoides folio cinereo*. *Pet. Gaz.* Tab. 84 fig. 12.  
*Pelargonium flavum* (L) Ait. (Geraniaceae) Folio 41
- I. *Geranium capense frutescens ribesii folio*. *Pet. Gaz.* 84 fig. 6.  
*Erodium* sp. (Geraniaceae) Folio 39

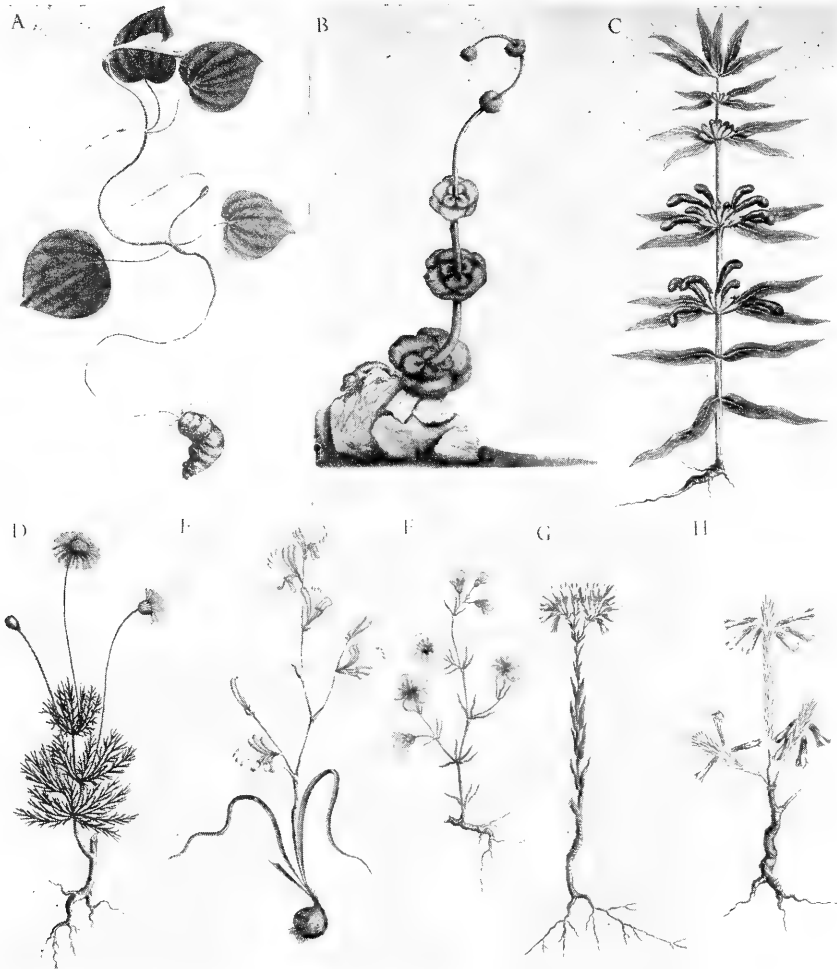


- PLATE 2A. *Ornithogalum umbellatum ornatissimum purpureum*. *Pet. Gaz.* Tab. 85, fig. 4.  
 "Father Tachard has figured this elegant shrub, but without leaves,  
 a tassel of which Mr. John Starrenburg sent me from thence"  
*Boophane* sp.? (Amaryllidaceae) Folio 87
- B. *Tulipa affinis capensis rubra caule maculato*. *Pet. Gaz.* Tab. 86 fig. 4.  
*Haemanthus* sp. (Amaryllidaceae) Folio 86  
 (Leaves and flowers appear separately)
- C. *Orchis capensis alba caule rubro maculato*. *Pet. Gaz.* Tab. 86 fig. 1.  
*Satyrium acuminatum* Lindl.? (Orchidaceae) Folio 69
- D. *Orchis capensis aurea foliis concavis*. *Pet. Gaz.* Tab. 85 fig. 1.  
*Satyrium striatum* Thunb.? (Orchidaceae) Folio 73
- E. *Ficoides capense apocyni folio flore magno coeruleo*. *Pet. Gaz.* Tab. 88, fig. 4.  
*Othonna* sp. (Compositae) Folio 88
- F. *Ficoides capens clavato folio flore aureo*. *Pet. Gaz.* Tab. 88 fig. 7.  
*Dorotheanthus* sp. (Mesembryanthemaceae) Folio 51
- G. *Aloe capensis cepa folio pinoides*. *Pet. Gaz.* Tab. 89 fig. 1.  
*Cotyledon wallichii* (Crassulaceae) Folio 66
- H. *Sedum capense frutescens folio subrotundo crasso*. *Pet. Gaz.* Tab. 89 fig. 4.  
*Cotyledon orbiculata* L. (Crassulaceae) Folio 61





- PLATE 3A. *Apocynum capense fritularicum minus*. *Pet. Gaz.* Tab. 90 fig. 4.  
*Stapelia variegata* L. (Asclepiadaceae) Folio 35
- B. *Elychrysium capense camphoratae foliis*. *Pet. Gaz.* Tab. 82 fig. 6.  
*Helichrysium* sp. (Compositae) Folio 25
- C. *Dens leonis, capensis barbareae folio*. *Pet. Gaz.* Tab. 81 fig. 2.  
*Othonna* sp. (Compositae) Folio [no number]
- D. *Euphorbium capense pinoides flore albo coronato, petalis in cisis*. *Pet. Gaz.* Tab. 90 fig. 2.  
*Euphorbia caput-medusae* L (Euphorbiaceae) Folio 60
- E. *Centarium capense folio angusto*. *Pet. Gaz.* Tab. 90 fig. 6.  
*Vauanthes dichotoma* (L.) Ok. (Crassulaceae) Folio 56
- F. *Bellis capensis umbellifera frutescens*. *Pet. Gaz.* Tab. 81 fig. 7.  
*Osmitopsis* sp. (Compositae) Folio 92
- G. *Ficoides capensis folio lato undulato flore purpureo*. *Pet. Gaz.* Tab. 88 fig. 5.  
*Othonna* sp. (Compositae) Folio 76
- H. *Elychrysium capense phalaroides pedis cati foliis minus*. *Pet. Gaz.* Tab. 82 fig. 3.  
*Helichrysium* sp. (Compositae) Folio 22



- PLATE 4A. *Tilianoides capensis* vaginis laicratis floribus luteis. *Pet. Gaz.* Tab. 90 fig. 8.  
*Aponogeton* sp. (Aponogetonaceae) Folio 85
- B. *Dolneus capensis* foliis ter trinis. *Pet. Gaz.* Tab. 90 fig. 9.  
*Crassula* sp. (Crassulaceae) Folio 77
- C. *Leonurus capensis* foliis non serratis. *Pet. Gaz.* Tab. 82 fig. 11  
*Leonotis* sp. (Labiatae) Folio 26
- D. *Cotula capensis* lutea ramosior. *Pet. Gaz.* Tab. 81 fig. 12.  
*Ursina* sp. (Compositae) Folio 12
- E. *Sisyrinchium capense* roseum ramosum. *Pet. Gaz.* Tab. 87 fig. 2.  
*Synnotia* sp.? (Iridaceae) Folio 78
- F. *Centaurium capense* luteum gallii foliis. *Pet. Gaz.* Tab. 90 fig. 5.  
*Pharnaceum* sp.? (Asclepiadaceae) Folio 46
- G. *Sedum capense* umbellatum flore albido. *Pet. Gaz.* Tab. 89 fig. 7.  
*Crassula* sp.? or *Rochea subulata* (Crassulaceae) Folio 47
- H. *Sedum capense* pinastri folio flore specioso aureo. *Pet. Gaz.* Tab. 89 fig. 5.  
*Erica* sp.? (Ericaceae) Folio 91

DETERMINATIONS OF PLANTS ILLUSTRATED IN DECADE 9 OF  
PETIVER'S GAZOPHYLACIUM

Tab. LXXXVII (77)

Fig. 3	?	(Mesembryanthemaceae)
Fig. 9	?	( " )
Fig. 10	Cephalophyllum sp. ??	

Tab. LXXXVIII (78)

Fig. 2	Conicosia sp.	(Mesembryanthemaceae)
Fig. 3	Aridaria sp.	( " )
Fig. 9	"	( " )
Fig. 10	Hydrodea sp.	( " )

Tab. LXXXI (79)

Fig. 1	Othonna	(Compositae)
Fig. 2	?	( " )
Fig. 3	?	( " )
Fig. 4	?	( " )
Fig. 5	Nidorella or Conyza	( " )
Fig. 6	Athanasia	( " )
Fig. 7	Osmitopsis	( " )
Fig. 9	?	( " )
Fig. 10	Gamolepsis	( " )
Fig. 11	Ursinia	( " )
Fig. 12	Ursinia	( " )

Tab. LXXXII (82)

Fig. 2	Helichrysum	(Compositae)
Fig. 3	Helichrysum sp.?	( " )
Fig. 4	Helichrysum sp.?	( " )
Fig. 5	? Selago?	(Selagineae)
Fig. 6	Metalasia muricata? Less	(Compositae)
Fig. 7	Scabiosa sp.?	(Dipsaceae)?
Fig. 8	Scabiosa sp.?	(Dipsaceae)?
Fig. 9	?	( " )
Fig. 10	Pteronia sp.	(Compositae)
Fig. 11	Leonotis sp.	(Labiatae)

Tab. LXXXIII (83)

Fig. 1	Cyphia bulbosa Berg.	(Campanulaceae)
Fig. 2	Aspalathus microphylla DC?	(Leguminosae)
Fig. 3	Lebeckia simsiana E & Z	( " )
Fig. 4	Indigofera sp.?	( " )
Fig. 5	Lotononis sp.?	( " )
Fig. 6	Lotononis sp.?	( " )
Fig. 12	Limonium sp.? or Drosera capensis?	(Plumbaginaceae)
		(Droseraceae)

Tab. LXXXIV (84)

Fig. 1	Xysmalobium undulatum R. Br.	(Asclepiadaceae)
Fig. 3	Asclepias sp.?	( " )
Fig. 5	Pelargonium angulosum Ait.	(Geraniaceae)
Fig. 6	Erodium sp.	( " )
Fig. 7	Pelargonium sp.	( " )
Fig. 8	Pelargonium echinatum (Thunb) Curt	( " )
Fig. 9	Pelargonium fulgidum Willd.	( " )
Fig. 10	Pelargonium triste (L) Ait.	( " )
Fig. 11	Pelargonium hirsutum (Burm.) Ait.	( " )
Fig. 12	Pelargonium flavum (L.) Ait.	( " )

Tab. LXXXV (85)		
Fig. 1	Satyrium striatum Thunb.?	(Orchidaceae)
Fig. 4	Boophane sp.? (Leaves and flowers should appear separately)	(Amaryllidaceae)
Fig. 5	Amaryllis belladonna L.	(Amaryllidaceae)
Fig. 6	Eucomis sp. or Whiteheadia	(Liliaceae)
Fig. 7	?	(Orchidaceae)
Tab. LXXXVI (86)		
Fig. 1	Satyrium acuminatum Lindl.?	(Orchidaceae)
Fig. 2	Satyrium sp.?	( " )
Fig. 3	Pterygodium sp.?	( " )
Fig. 4	Haemanthus sp. (Leaves and flowers should appear separately)	(Amaryllidaceae)
Fig. 5	Euphorbia loricata Lam.	(Euphorbiaceae)
Fig. 6	Euphorbia hamata	( " )
Tab. LXXXVII (87)		
Fig. 1	Gladiolus carinatus Ait.	(Iridaceae)
Fig. 2	Synnotia sp.?	( " )
Fig. 3	?	( " )
Fig. 4	Drimia sp.?	(Liliaceae)
Fig. 5	Wurmbea spicata (Burm.) Dur.	( " )
Tab. LXXXVIII (88)		
Fig. 1	Aloe variegata Linn	(Liliaceae)
Fig. 2	Aloe melanacantha Berger	( " )
Fig. 3	Aloe Khamiesensis? Pillans	( " )
Fig. 4	Othonna sp.	(Compositae)?
Fig. 5	Othonna	( " )
Fig. 6	?	(Mesembryanthemaceae)
Fig. 7	Dorotheanthus	( " )
Fig. 8	?	( " )
Fig. 9	?	( " )
Tab. LXXXIX (89)		
Fig. 1	Cotyledon wallichii	(Crassulaceae)
Fig. 2	Cotyledon	( " )
Fig. 3	? Aloe plicatilis	(Liliaceae)
Fig. 4	Cotyledon orbiculata L.	(Crassulaceae)
Fig. 5	Erica sp.?	(Ericaceae)
Fig. 6	? Crassula	(Crassulaceae)
Fig. 7	Crassula? or Rochea subulata	( " )
Fig. 8	Agathosma sp.?	(Rutaceae)
Fig. 9	Diosma sp.?	( " )?
Tab. XC (90)		
Fig. 1	Euphorbia caput-medusae L.	(Euphorbiaceae)
Fig. 2	Euphorbia stellispina Haw.	( " )
Fig. 3	Euphorbia sp.	( " )
Fig. 4	Stapelia variegata L.	(Asclepiadaceae)
Fig. 5	Pharnaceum?	( " )
Fig. 6	Vauanthes dichotoma (L) Ok.	(Crassulaceae)
Fig. 7	Erica sp.?	(Ericaceae)
Fig. 8	Aponogeton sp.	(Aponogetonaceae)
Fig. 9	Crassula sp.	(Crassulaceae)

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## BOOK REVIEW

XYLOTOMY OF THE LIVING CYCADS by Pál Greguss pp. 260 + 950 microphotographs and 79 drawings on 185 plates, 80 text figures and a map. (Budapest: Akademiai Kiadó 1967) \$18.00.

This work is a direct continuation of the same author's monograph on the Identification of Living Gymnosperms on the Basis of their Xylotomy published in Acta Bot. Hung. vol. 10, pp. 127-144 (1964). The present work is divided into two parts. Part one deals with the Xylotomy of the trunk, first in cross-section, then in tangential section followed by characters of their radial structure. In part two it is the epidermis of the leaves which is dealt with in detail.

The most characteristic common feature of the trunks of Cycads are the well-developed pith system, the comparatively narrow conductive bundle system, the well-developed cortical zone and the mucilage canals meandering in the pith and cortex.

It is of interest also that Greguss accepts differences in the density and structure of stomata as of sufficient importance to uphold the specific status of *Stangeria paradoxa* T. Moore, as opposed to the view that it represents merely an ecological form of *S. eriopus* (Kunze) Nash.

In considering the geographical distribution of living Cycads, Greguss states that some evidence suggests the former presence of a vast Gondwanaland continent. At the same time he accepts negative evidence to disbelieve the theory of continental drift.

The present work is not without its significance in the field of paleobotany, an aspect of which is the subject of the review of the author's work on the Fossil Gymnosperm Woods in Hungary in Journ. S.A. Bot. Vol. 34, 3, p. 201 (1968). In the classification of Cycad fossils it is mainly the anatomical characters of the trunks and of the leaf epidermis which become available for study. Greguss gives several examples where the epidermal structure of living and extinct cycads is remarkably similar. Among these examples are *Encephalartos lehmannii* Lehm. from the eastern Cape Province and the fossil *Callipteris martensii*. And another example of close similarity is between *Stangeria paradoxa* T. Moore from the coastal districts of the eastern Cape and Natal and extinct species of the genus *Ctenis*.

As is his practice, the author has made full use of illustrations to support the 251 pages of text. There are no less than 950 microphotos and 79 line drawings on the 185 well reproduced plates. In addition there are 80 figures and a distribution map within the text. The text deals with all 10 genera of living Cycads and African species are particularly well represented. Thirty-one species of *Encephalartos* are dealt with including almost the full range of 26 species from South Africa, even to *E. inopinus* R. A. Dyer, published first in Bothalia 1965.

For anyone making a critical study of the Cycads of the world, or of different continents for that matter, this is an indispensable work of reference. It has particular significance for workers in southern Africa.

R. A. DYER





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'n ANATOMIESE EN ONTOGENETIESE  
STUDIE VAN DIE WORTELS VAN  
SUID-AFRIKAANSE LILIACEAE:

V. DIE ONTWIKKELING VAN PERIDERM BY 'N PAAR SOORTE.\*†

K. J. PIENAAR

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ABSTRACT

In the present study the development of periderm was observed in the perennial roots of some of the species investigated of the Liliaceae occurring in South Africa. In two species the development of wound periderm was observed.

The phellogen originates in the cortical layer(s) next to or very close to the exodermis. The periderm eventually becomes the outer protective tissue of the root. Many more layers of phellem than phelloderm are formed.

INLEIDING

Geen besonderhede oor die ontwikkeling van periderm by die wortels van Liliaceae-soorte kon in die beskikbare literatuur opgespoor word nie. Dat periderm wel ontwikkel in die wortels van sommige monokotiele is reeds lank bekend. Hieroor skryf Arber (1925) soos volg: „A very general difference between monocotyledonous and dicotyledonous roots lies in the fact that in monocotyledons the periderm is commonly superficial, while in dicotyledons it is, as a rule, pericyclic. Priestley and his colleagues' interesting work on the endodermis throws some light on this distinction. According to their views,

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\* Deel van 'n verkorte weergawe van 'n proefskrif goedgekeur vir die graad van Doktor in die Natuurwetenskappe aan die Universiteit van Stellenbosch, September 1965.

† Aanvaar vir publikasie 17 Julie 1968.

the endodermis in many plants in its 'secondary' stage is rendered impermeable to water and to solutes by the presence of a suberin lamella on the inner surface of the cell wall. When the walls of all the endodermal cells suffer this change, a cork layer commonly arises in the pericycle—the necessary meristematic activity being stimulated by the accumulation of sap within the endodermal barrier. If, on the other hand, some of the cells fail to pass over into the 'secondary' condition, and remain as 'passage' cells, the endodermis is an ineffectual barrier, and no sap accumulates within it. But the exodermis, within the piliferous layer, is often impenetrable, and so the sap, after passing freely through the endodermis, may be held up at the exodermis, with the result that cork formation occurs in the outer cortical layers”.

#### MATERIAAL EN METODES

Sien Pienaar (1968 a, p. 38—39 en 1968 b, p. 92—93).

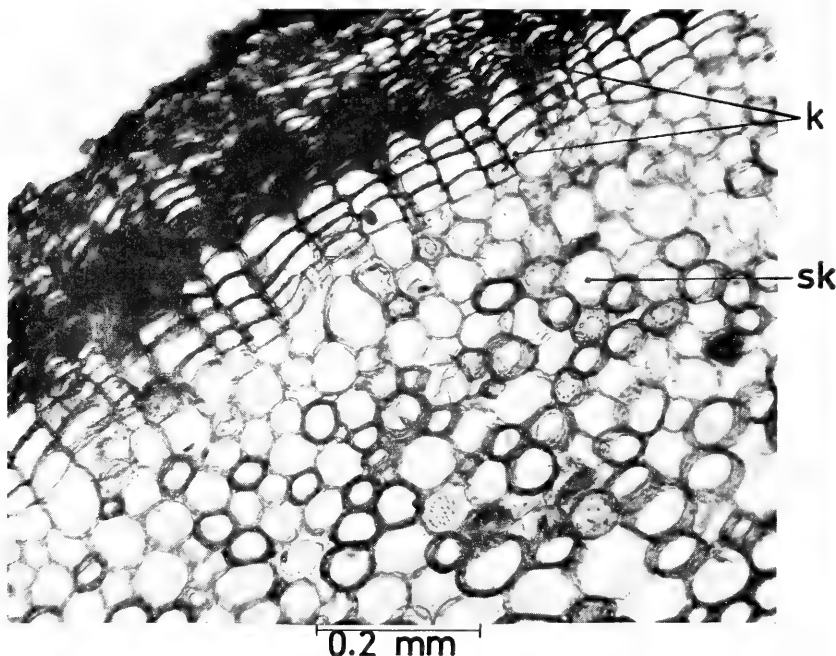


Fig. 1. *Aloe arborescens*. Dwarssnee van die kurklae en die buiteskors in 'n ou wortel: k, kurklae; sk, skors wat bestaan uit dunwandige en dikwandige parenchiemselle. Let op die radiale rangskikking van die kurkselle.

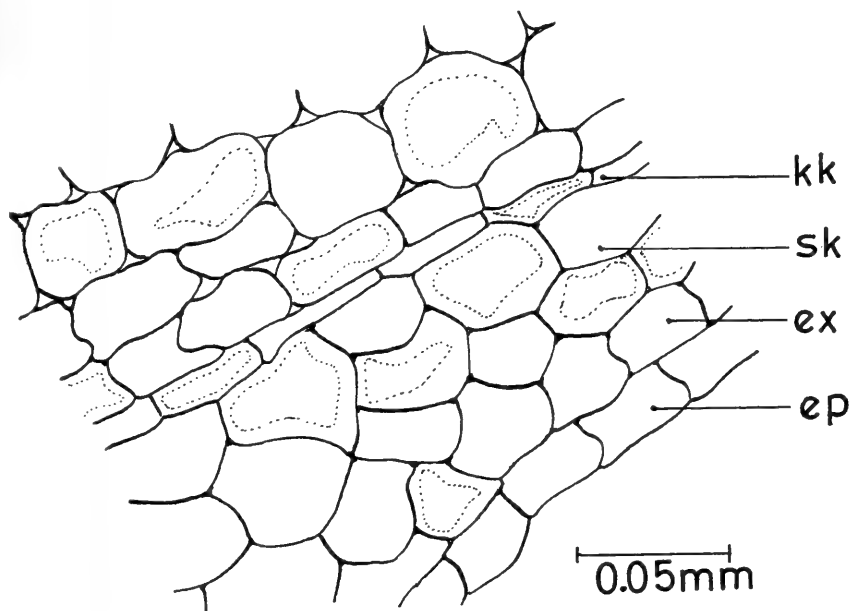


Fig. 2. *Aloe ciliaris*. Dwarssnee van die buitendeel van die wortel: ep, epidermis, ex, eksodermis; kk, fellogeen begin differensieer in die buiteskors; sk, skorsparenchiem.

#### ONDERSOEK EN BESPREKING

In die huidige studie is die ontwikkeling van periderm waargeneem by die volgende ondersoekte soorte:

*Aloe arborescens* Mill.

*A. ciliaris* Haw.

*Gasteria pillansii* Kensit.

*Haworthia truncata* Schönl.

*Sansevieria longiflora* Sims.

By die meerjarige wortels van die bg. soorte is vasgestel dat die periderm ontwikkel uit die buitenste sellae van die skors, m.a.w. die periderm ontstaan eksogeen en nie endogeen uit die perisikel soos by wortels van meeste dikotiele nie. Die huidige bevinding stem dus ooreen met dié van Arber (1925).

Die ontwikkeling van periderm by *Aloe arborescens* (fig. 1) is besonder duidelik. Die fellogeen begin differensieer in die skorslaag teenaan die eksoder-

mis. By *A. ciliaris* (fig. 2), *Gasteria pillansii* (fig. 3) en *Sansevieria longiflora* (fig. 4) differensieer die fellogeen nagenoeg in die vierde skorsellaag vanaf die epidermis.

In die ou wortel van *Aloe arborescens* (fig. 1) bestaan die felleem uit ongeveer twaalf platgedrukte sellae. Die selle is betreklik groot, die selwande dun en verkurk en intersellulêre ruimtes is afwesig. Sommige van die selle bevat 'n donker, onbekende inhoud.

Behalwe by *Aloe ciliaris* (fig. 2) kon die fellogeen nie as 'n duidelik aan-enlopende sellaag onderskei word nie.

By al die ondersoekte soorte begin die ontwikkeling van die periderm min of meer aan die einde van primêre ontwikkeling van die wortels. Die epidermis en die eksodermis verdwyn geleidelik en die periderm vorm dus uiteindelik die beskermende mantel van die wortel. Meer felleemlae as fellodermlae word gevorm.

Arber (1925) verwys na die navorsing van Priestley en sy kollegas i.v.m. die mate van verdikking en verkurking van die wande van die endodermiselle en die moontlike rol wat dit mag speel in die plek waar die fellogeen gaan differensieer. (Sien Inleiding.)

Die endodermiselle van die huidig ondersoekte soorte vertoon aldrie moontlike stadia van ontwikkeling, nl. primêr, sekondêr en tersiêr. Indien lg. twee toestande voorkom is daar in elk geval dunwandige deurlaatselle en/of eenvoudige stippels in die verdikte, verhoude selwande aanwesig. Volgens Priestley, soos aangehaal deur Arber (1925), sal die endodermis dus in hierdie

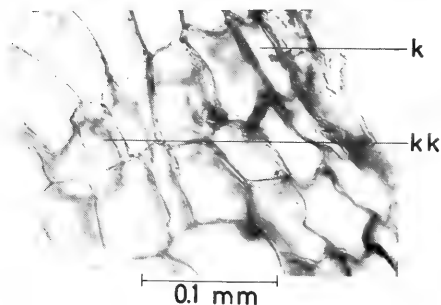


Fig. 3.

Fig. 3. *Gasteria pillansii*. Dwaarsnee van die kurklae in die buitedeel van die wortel: k, felleem; kk, moontlike fellogeensel.

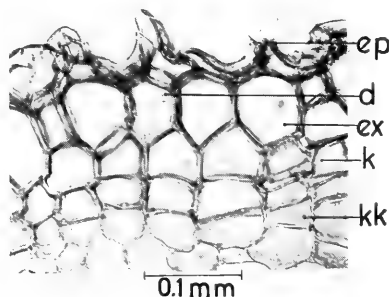


Fig. 4.

Fig. 4. *Sansevieria longiflora*. Dwaarsnee van die kurklae in die buitedeel van die wortel: d, deurlaatsel in die eksodermis met 'n protoplasmatiese inhoud; ep, oorblyfsels van die epidermis; ex, eksodermis; k, felleem; kk, fellogeen.

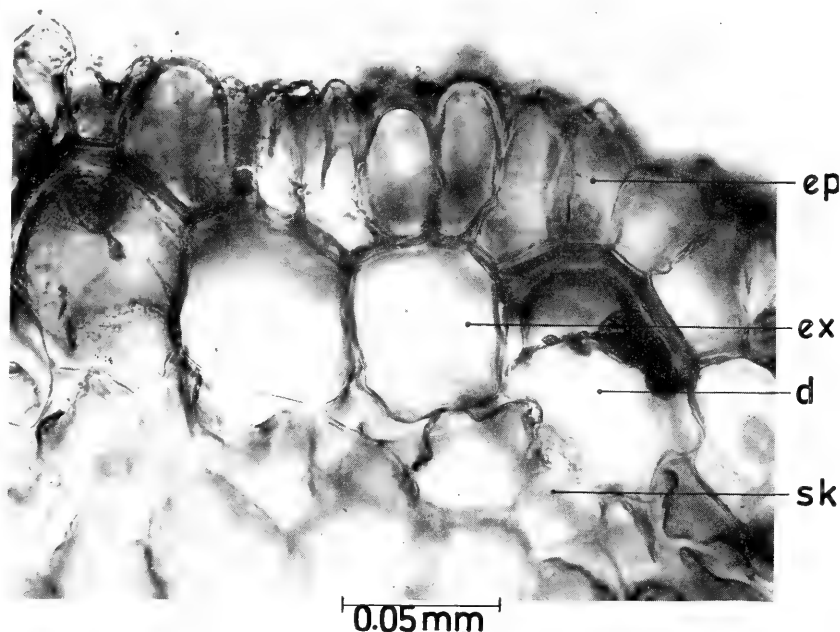


Fig. 5. *Aloe arborescens*. Dwarssnee van die buitelaai van die jong wortel voordat sekondêre ontwikkeling plaasvind: d, deurlaatsel met 'n protoplasmatische inhoud en 'n sterk verdikte buitenste tangensiale wand; ep, epidermis; ex, eksodermis; sk, parenchimatiese skors. Let op die verdikte buitenste tangensiale wande van die epidermis.

soorte 'n ondoeltreffende afsluitingslaag t.o.v. water en opgeloste stowwe vorm. Aan die binnekant van die endodermis sal dus geen opeenhoping van sap wees nie en sal die perisikel of ander parenchiemselle waarskynlik nie tot meristematie aktiwiteit gestimuleer word nie. Fellogeen sal dus nie hier differensieer nie.

Die wande van die eksodermiselle van die huidig ondersoekte soorte is deurgaans verkurk, hetsy of hulle dun- of dikwandig is. By *Sansevieria longiflora* is die eksodermis meer as een sellag breed. Behalwe by *Haworthia truncata* bestaan die eksodermis uit groot selle en kleiner deurlaatselle. Lg. besit 'n protoplasmatische inhoud. Die buitenste tangensiale wande van die deurlaatselle in die eksodermis van die jong wortel van *Aloe arborescens* (fig. 5), is aansienlik verdik en verkurk.

Uit bostaande kenmerke wil dit dus voorkom of die eksodermis van die huidig ondersoekte soorte wel, in 'n groot mate, ondeurdringbaar kan wees vir water en opgeloste stowwe wat deur die endodermis na buite sou kon beweeg.

Of die opeenhoping van water en voedsel in die skorslae teenaan die eksodermis enige meristematische aktiwiteit in daardie skorsselle stimuleer, is nie duidelik nie. In hierdie verband kan verwys word na die meerlagige, dikwandige en verkurkte eksodermis by *Bulbine caulescens*, *Asparagus compactus* en *Dracaena hookeriana* (vgl. Pienaar, 1968 b, p. 106), wat by uitstek ondeurdringbaar mag wees vir water en opgeloste stowwe, en tog ontwikkel by hierdie soorte geen periderm nie. In 'n dwarsnee kan die periderm redelik maklik onderskei word van die meerlagige eksodermis. Die peridermselle is radiaal gerangskik en tangensiaal baksteenvormig afgeplat, terwyl dit nie die geval is met die meerlagige eksodermisselle nie.

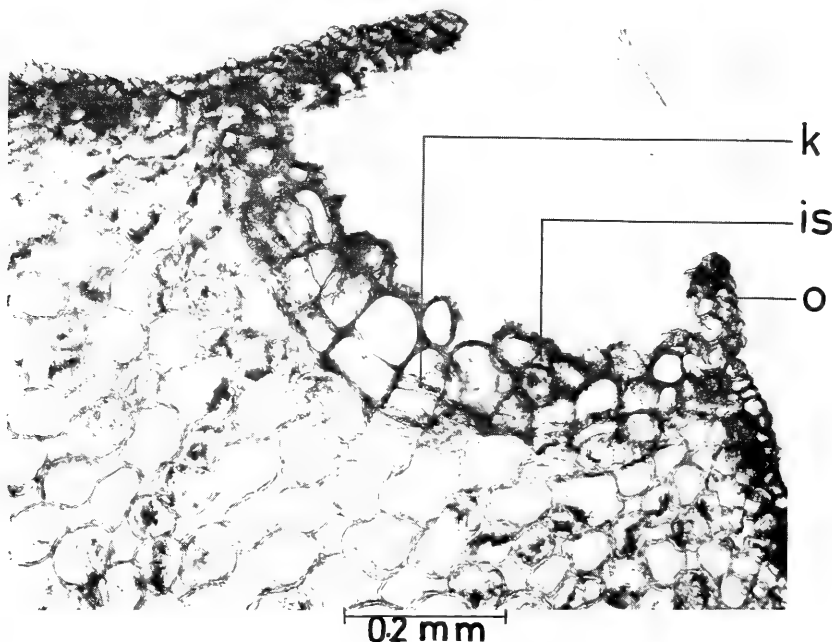


Fig. 6. *Kniphofia ensifolia*. Dwarssnee van die buitenste gedeelte van die wortel om die ontwikkeling van wondperiderm te illustreer: is, intersellulêre ruimte; k, felleem, sowat 3—4 sellae breed; o, oorblyfsels van die epidermis en die buitelaag(lae) van die skors.

Die ontwikkeling van wondperiderm is waargeneem by *Veltheimia deasii* Barnes en *Kniphofia ensifolia* Baker (fig. 6). Ook in hierdie gevalle differensieer die fellogeen in die buitenste skorslae en is die kurkselle radiaal gerangskik.

#### OPSOMMING

1. Die ontwikkeling van periderm kom voor by die blywende wortels van sommige soorte van die Liliaceae.
2. Die fellogeen differensieer in die buitenste skorslaag(lae) teenaan of naby aan die eksodermis.
3. Die moontlike rol wat die deurlaatbaarheid van die endo- en die eksodermisselle speel by die differensiasie van die fellogeen, is nie duidelik nie.
4. Meer felleemlae as fellodermlae word gevorm.
5. Die felleemselle is dunwandig en sonder intersellulêre ruimtes.
6. Die periderm vorm by die ou wortels die beskermende mantel van die wortel.

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# A NOTE ON THE PROBABLE IDENTITY OF *ACACIA SCHLECHTERI* HARMS†

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Harms in Engl. Bot. Jahrb. 51 : 367 (1914) described *Acacia schlechteri* from the specimen, *Schlechter* 11901, collected at Ressano Garcia in Mozambique. Unfortunately the type specimen was destroyed and, as far as is known, no specimens that were compared with the type exist. Few specimens have been subsequently referred to *A. schlechteri* and those usually with some doubt. This, however, is not surprising for *A. schlechteri* forms part of the difficult complex comprising *A. burkei* Benth., *A. rovumae* Oliv., *A. nigrescens* Oliv., *A. welwitschii* Oliv., *A. goetzei* Harms and *A. delagoënsis* Harms. Within this complex the degree of pubescence of the calyx is the character of prime importance which distinguishes between two groups: *A. burkei* and *A. rovumae* alone have pubescent calyces.

Harms mentioned the similarity between *A. schlechteri* and *A. welwitschii*. However, *A. schlechteri* apparently differed in having minutely puberulous flowers and, presumably calyces, although this is not clear from the type description "spicae apice ramulorum breviter paniculatae, elongatae, minute puberulae, 5–9 mm longae." The fruit of *A. schlechteri* was unknown to Harms. Young's (Candollea 15:123, 1955) description of *A. schlechteri* adds little to the knowledge of the species since his general description is based on that of Harms whilst the specimen, *Rogers* 18537 (PRE), on which he based his description of the fruit is *Albizia anthelmintica* Brongn.

Whilst examining specimens within this complex of species only one, namely *Torre* 2055 (LISC), from the neighbourhood of Goba in Mozambique answered the description of *Acacia schlechteri*, agreeing in having sparingly puberulous calyces. However, apart from being sparingly puberulous throughout the specimen was indistinguishable from, and shared the characteristic leaflet shape of, *A. welwitschii* subsp. *delagoënsis* (Harms) Ross & Brenan (Kew Bull. 21 : 67 1967). The specimen bore little resemblance to *A. burkei* or to *A. rovumae* which characteristically have pubescent leaves and calyces. Consequently *Torre* 2055

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(LISC) is probably best considered as a sparingly puberulous variant of *A. welwitschii* subsp. *delagoënsis*. More material from the type locality of *A. schlechteri* is desirable in order to establish the incidence of the sparingly puberulous specimens but from the information at present available *A. schlechteri* is provisionally regarded as a synonym of *A. welwitschii* subsp. *delagoënsis*.

# NOTES ON SOUTH AFRICAN MARINE† ALGAE. V.

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Earlier papers in this series (1940, 1943, 1952, 1956) dealt with questions relating to the identity, taxonomy, and nomenclature of some of the South African green, brown, and red marine algae. The present article deals with questions relating exclusively to red algae.

Grateful acknowledgment is made to the Carnegie Corporation of New York for a Grant-in-Aid, received through the University of Cape Town (1939–1940), the Guggenheim Foundation for a Fellowship (1949–1950), and the National Science Foundation for a Grant-in-Aid (1954–) which enabled me to search for (in European herbaria) and to study the types and other published specimens referred to in this article. Funds granted by the National Science Foundation and the University of California have also made it possible to secure the services of research assistants to aid in the study of the South African marine algae. I wish to thank Dr. Shirley Sparling and Dr. Young-Meng Chiang for valuable assistance. For the loan of specimens, I am indebted to the keepers of the following herbaria: British Museum (Natural History); Bolus Herbarium, University of Cape Town; Rijksherbarium, Leiden; Muséum National d'Histoire Naturelle, Laboratoire de Cryptogamie, Paris; National Herbarium of Victoria, Melbourne; Naturhistoriska Riksmuseum, Stockholm; and Naturhistorisches Museum, Vienna.

## ***Antithamnion densum* (Suhr) Howe**

Suhr in 1840 (p. 281) described a species from Peru under the name *Callithamnion densum*. Howe (1914, p. 151) has referred this species to the genus *Antithamnion*.

J. Agardh (1851a, p. 66) mentioned *Callithamnion densum* under "*Species inquirendae*" and gave Peru as its locality. Later (1876, p. 51) he again included it under "*Species inquirendae*" but in error gave South Africa instead

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of Peru as the locality. Barton (1893, p. 114) on the authority of J. Agardh included the species in her list of the marine algae of South Africa. The species, as far as known, does not occur in South Africa.

**Aristothamnion collabens** (Rudolphi) Papenfuss, comb. nov.

*Asperocaulon collabens* Rudolphi, 1831, p. 178. Suhr, 1834, p. 741.

*Aristothamnion purpuriferum* (Kützinger) J. Agardh, 1892, p. 45. Barton, 1893, p. 114.

*Phlebothamnion purpuriferum* Kützinger, 1849, p. 656; 1862, p. 3, pl. 7, figs. c–e.

*Pleonosporium purpuriferum* (Kützinger) DeToni, 1903, p. 1307.

*Callithamnion purpuriferum* (Kützinger) J. Agardh, 1851a, p. 59.

*Phlebothamnion squarrosus* Kützinger, 1849, p. 659; 1862, p. 5, pl. 15, figs. a–c.

*Callithamnion squarrosus* (Kützinger) J. E. Areschoug, 1854, no. 56.

*Phlebothamnion compressum* Kützinger, 1864, p. 32, pl. 91, figs. c and d.

*Callithamnion compressum* (Kützinger) DeToni, 1903, p. 1334.

*Dasya collabens* sensu Barton, 1893, p. 175 (non J. D. Hooker et Harvey).

This species has suffered much taxonomic and nomenclatural confusion. It has become well known as *Pleonosporium purpuriferum* (Kützinger) DeToni, but it was first described as *Asperocaulon collabens* by Rudolphi in 1831 and this specific name has priority.

Kützinger in 1849 (pp. 656 and 659) described the species as *Phlebothamnion purpuriferum* and *P. squarrosus*, and for a third time in 1864 as *P. compressum*. Barton (1893) in error associated *Asperocaulon collabens* Rudolphi with *Dasya collabens* J. D. Hooker et Harvey, a species from New Zealand.

Evidently it, at first, was Rudolphi's intention to call the species *Asperocaulon compressum* (he described it in part as “. . . siccitate ramisque compresso-planis. . .”) and, as so often happens, he forgot to change the name to *collabens* on the pieces of paper bearing the specimens. Kützinger's (1849) description and subsequent (1862) illustrations of *Phlebothamnion squarrosus* are based on a Rudolphi specimen which bears the name “*Asperocaulon compressum*”, a binomial cited and credited to Rudolphi by Kützinger (1949). Kützinger's material is accompanied by a label to the effect that the plant occurred on *Sphaerococcus dilatatus* (= *Gymnogongrus dilatatus*), one of the hosts mentioned by Rudolphi in his description of *A. collabens*. With Harvey's specimens of *Callithamnion purpuriferum* at Trinity College, Dublin, is a note that reads: “This is *Asperocaulon compressum* Rudolphi! fide Herb. Binder!” I have selected the Rudolphi specimen illustrated by Kützinger (1862, pl. 15, fig. a) as lectotype of *Asperocaulon collabens* Rudolphi.

In 1892 J. Agardh erected the genus *Aristothamnion* for *Phlebothamnion purpuriferum* Kützinger. This genus was reduced to a synonym of *Pleonosporium* (Nägeli) Nägeli ex Hauck by DeToni (1903, p. 1303). Baardseth (1941), on the

basis of his own work on a new species, *Aristothamnion ramellifera*, from Tristan da Cunha and on that of Westbrook (1927) on the species from South Africa, argued for the retention of *Aristothamnion*. He has been followed by Kylin (1956, p. 383) and Simons (1960), and I am also following him.

### ***Chaetangium erinaceum* (Turner) Papenfuss**

*Chaetangium erinaceum* (Turner) Papenfuss, 1952, p. 173.

*Chaetangium dichotomum* Kützing, 1869, p. 18, pl. 48, figs. c-f.

*Chaetangium hystrix* (C. Agardh) Kützing, 1849, p. 793 (only as to South African material, not as to type of *Grateloupia hystrix* C. Agardh, 1822, p. 223).

Examination of Kützing's (1869) type of the little-known *Chaetangium dichotomum*, described on the basis of material from South Africa, has revealed that it is one of the many morphological expressions of *C. erinaceum*.

In a previous paper (1944) I discussed the probable source of the species described by C. Agardh (1822) as *Grateloupia hystrix*, the basionym of *Gigartina hystrix* (C. Agardh) Setchell et Gardner (1933), and pointed out that the type probably was collected at Monterey, California. The South African material that Kützing (1849; see also 1869, p. 18, pl. 49, figs. a-d) in error associated with *Grateloupia hystrix* when he made the combination *Chaetangium hystrix*, is in his collection at Leiden and is representative of *Chaetangium erinaceum* (Turner) Papenfuss.

### ***Chamaethamnion schizandra* Falkenberg**

When describing this parasitic genus and species of Rhodomelaceae, Falkenberg (*in* Schmitz and Falkenberg, 1897, p. 449) gave the South African and Australian seas as the places of occurrence of the species, and *Polysiphonia nigrita* Sonder (= *P. cancellata* Harvey) as its host. In 1901 (p. 579) Falkenberg referred only to material from Australia. Kylin (1956, p. 519), in his *Gattungen der Rhodophyceen*, accepts the distribution of this monotypic genus as given by Falkenberg in 1897. However, as far as known, neither *Chamaethamnion schizandra* nor its host occurs in South Africa.

### ***Chondria armata* (Kützing) Okamura**

*Chondria armata* (Kützing) Okamura, 1907, p. 69, pl. 16, figs. 9-19. Weber-van Bosse, 1923, p. 353. Børgesen, 1932, p. 132, figs. 17 and 18.

*Lophura armata* Kützing, 1866, p. 2, pl. 3, figs. a and b.

*Rhodomela crassicaulis* Harvey, Ceylon algae no. 8 (nomen nudum). Svedelius, 1906, p. 191, figs. 3 and 9, pl. 6, fig. A.

*Chondria minima* Weber-van Bosse, 1921, p. 309, pl. 7, fig. 9.

Specimens of this species, which is here reported for the first time from South Africa, were collected at Port Shepstone on 27 July 1938 by Dr. Pocock

and me and at Chakas Rock (north of Durban) by Dr. Pocock (her no. 9526) on 14 October 1951.

*Chondria armata* was established by Kützing (1866) as *Lophura armata* on the basis of material from New Caledonia. The species is also known from Japan, Indonesia, southern India, and Ceylon. The South African plants agree well with published accounts and illustrations of the species and with specimens of it from Japan, India, and Ceylon in the herbarium of the University of California.

### ***Dasyopsis pinnatifolia* (Suhr) Schmitz**

*Dasyopsis pinnatifolia* (Suhr) Schmitz, 1893, p. 231; 1894, p. 194.

*Ptilota? pinnatifolia* Suhr, 1834, p. 732, pl. 2, figs. 18 and t.

*Carpoblepharis pinnatifolia* (Suhr) Kützing, 1847, p. 1; 1849, p. 691; 1862, pl. 60, figs. d and e. Delf and Michell, 1921, p. 116.

*Dasya pinnatifolia* (Suhr) Schmitz, 1893, p. 230, f.n.1.

*Sarcomenia? sandersoni* Harvey ex J. Agardh, 1896, p. 137.

The herbarium of the University of Kiel contains a fine specimen of the original material of "*Ptilota? pinnatifolia* S." from "Algoa Bai" (filed under *Carpoblepharis*) which I have chosen as lectotype of this species. The Botanical Museum of Stockholm also has a sheet, containing three fragments, of the original material. Tyson's collection in the Bolus Herbarium contains a specimen from Algoa Bay, reported by Delf and Michell (1921) as *Carpoblepharis pinnatifolia*, but the collector's name is not given on the sheet.

The little-known *Sarcomenia? sandersoni* Harvey ex J. Agardh (1896) which is based on a specimen from Port Natal, has been found to be conspecific with *Dasyopsis pinnatifolia*. A relationship with *Dasyopsis plana*, the lectotype of *Dasyopsis*, was already suspected by J. Agardh when he described *S. sandersoni*. I am indebted to Dr. H. B. S. Womersley, who saw a specimen in Harvey's collection at Trinity College, Dublin, for bringing this species, which I had overlooked, to my attention. He also kindly sent me a fragment of the plant. In 1959, when Dr. M. A. Pocock visited Dublin, she kindly made for me a sketch of Harvey's specimen. At my request Dr. Peter Dixon in 1958 looked at the material of this taxon in the Agardh Herbarium. He found that only a minute fragment was present, no. 44318. I am, therefore, designating the specimen in Harvey's collection at Dublin as lectotype of *S. sandersoni*.

*Dasyopsis pinnatifolia* is a rare species which, in addition to the three collections mentioned above, has been collected, as far as I am aware, only by Dr. Pocock. She obtained it in the drift at Sharks Bay, Port Alfred, on 19 March 1961 and kindly sent me a small piece of a male plant preserved in formalin.

***Galaxaura corymbifera* Kjellman**

*Galaxaura corymbifera* Kjellman, 1900, p. 87, pl. 19, figs. 21–27 and pl. 20, fig. 50. Kylin, 1938, p. 6, fig. 1F, pl. 2, fig. 5.

*Galaxaura breviarticulata* Kjellman, 1900, p. 84, pl. 18, figs. 1–13 and pl. 20, fig. 51.

*Galaxaura effusa* Kjellman, 1900, p. 84, pl. 18, figs. 14–18, pl. 20, fig. 52.

*Galaxaura obtusata* sensu Krauss, 1846, p. 214. Sensu Areschoug, 1851, p. 22. Sensu Kützing, 1858, p. 16, pl. 35, fig. I. Sensu Barton, 1893, p. 144. Sensu Delf and Michell, 1921, p. 102.

*Galaxaura umbellata* sensu J. Agardh, 1876, p. 526, pro parte.

*Galaxaura oblongata* sensu Kützing, 1858, p. 16, pl. 35, fig. II.

Kjellman (1900) described this plant under three names: *Galaxaura corymbifera*, *G. breviarticulata*, and *G. effusa*. Through the work of Kylin (1938), DeValéra (1938), and especially that of Svedelius (1942), the species has become well known as *G. corymbifera* and I have, therefore, adopted this name.

Formerly (Krauss, 1846; Areschoug, 1851; Kützing, 1858; Barton, 1893; Delf and Michell, 1921) the South African plant was usually referred to *Galaxaura obtusata*, a species based on a plant from the West Indies which apparently does not occur in South Africa.

***Galaxaura diesingiana* Zanardini**

*Galaxaura diesingiana* Zanardini, 1846, p. 51; 1862, p. 475, pl. 31, figs. B1–B5.

*Galaxaura beckeri* Schmitz ex Mazza?, 1906, p. 3.

*Galaxaura natalensis* Kylin, 1938, p. 6, fig. 1E and pl. 2, fig. 4.

*Galaxaura marginata* sensu Krauss, 1846, p. 214.

*Zanardinia marginata* sensu Barton, 1893, p. 171 (pro parte).

*Zanardinia marginata* b. *diesingiana* (Zanardini) J. Agardh, 1876, p. 534.

*Brachycladia marginata* f. *diesingiana* (Zanardini) DeToni, 1897, p. 110.

*Euhymenia capensis* Kützing, 1849, p. 742.

The genus *Galaxaura* and especially *G. diesingiana*, as far as its South African representatives are concerned, have suffered a great deal of misunderstanding. Much of the misunderstanding has stemmed from the fact that Kjellman (1900), the monographer of the genus, treated the sexual and tetrasporangial phases of the plants as representative of different species; and many workers even today follow the example set by Kjellman. Howe (1917, 1918) was the first to bring attention to the fact that gametophytic and sporophytic plants of species of *Galaxaura* differ from each other in the structure of the cortex. Svedelius (1942), in his paper on the South African species of *Galaxaura*, cast further light on the dimorphism that exists in the genus.

*Galaxaura diesingiana* was described by Zanardini on a tetrasporangial

plant which was collected by Pöppig at Port Natal and sent to him by Diesing. I have not seen Zanardini's type but have seen the isotypes (3 on one sheet) in Diesing's collection in the Natural History Museum of Vienna.

*Galaxaura beckeri* was described by Mazza (1906) on the basis of material collected by Becker at The Kowie (Port Alfred). The name had been proposed by Schmitz (who did not live to publish it) and Becker distributed specimens of the plant under this name. According to DeToni (1924, p. 136) *G. beckeri* is the same as *G. diesingiana*. However, the somewhat similar *G. magna* Kjellman (1900) is also occasionally obtained at Port Alfred and it is necessary that Mazza's type be examined before it can be stated with certainty that *G. beckeri* is a synonym of *G. diesingiana*. The specimen of *G. beckeri* illustrated by Kylin (1938, pl. 1, fig. 3) is *G. diesingiana* and so are two of the three specimens under the name *G. beckeri* in the Tyson Collection (Delf and Michell, 1921, p. 103) of the Bolus Herbarium, the third being representative of *G. magna*.

*Galaxaura natalensis* was described by Kylin (1938) on a female plant of *G. diesingiana*. The material reported by Krauss (1946) as *G. marginata* also is representative of *G. diesingiana* (specimens seen in S, BM, and W) and the record by Barton (1893) of *Zanardinia marginata* is based, in part (i.e. the Carr, Flanagan, Krauss, and Gueinzus specimens), on *G. diesingiana*.<sup>1</sup> As far as known *G. marginata* (Ellis et Solander) Lamouroux, which is based on a specimen from the Bahama Islands, does not occur in South Africa.

Another taxon that is conspecific with *Galaxaura diesingiana* is the species described by Kützing (1849) as *Euhymenia capensis*. The type of this species is not in Kützing's collection at Leiden. However, I received on loan from the National Herbarium of Victoria, Melbourne, a specimen labelled "Euhymenia capensis Kütz. Kallymenia—J. Ag. Port Natal". This specimen agrees well with Kützing's (1849, p. 742) diagnosis of *E. capensis* and I have chosen it as lectotype of this species.

In 1867 Kützing illustrated a plant in volume 17 of his *Tabulae phycologicae* (pl. 74) under the name *Euhymenia capensis*. This specimen is in Kützing's collection at Leiden. However, it was not collected by Gueinzus at Port Natal, as stated by Kützing on page 22 of this volume, but at "Elim". Elim is an inland Moravian Mission Station not far from Struis Bay and Cape Agulhas and it may be assumed that the specimen was collected by a member of the Mission in the vicinity of Struis Bay or Cape Agulhas. This specimen is representative of *Anatheca dentata* (Suhr) Papenfuss (1940, p. 218), of which I collected specimens in the drift at Struis Bay in February 1937.

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<sup>1</sup> The Hohenacker specimen cited by Barton is an isotype of *G. magna* Kjellman and the Bowerbank specimen is representative of *G. tenera* Kjellman. The specimens cited by Barton are all in the herbarium of the British Museum (Natural History).



*Euhymenia capensis* has been the cause of a good deal of confusion. Presumably on the basis of Kützing's illustration of the habit of the plant which he in 1867 misidentified as *E. capensis*, J. Agardh in 1892 (p. 67) made the combination *Kallymenia capensis*. The material that J. Agardh had in hand (nos. 24713 and 24715 in Herbarium Agardh) was of a cryptonemiaceous plant (sent to him by Holmes) that is common in the drift at Port Alfred. The same species was reported from South Africa under the name *K. capensis* by Barton (1893, p. 140), as *Cryptonemia ? capensis* by Barton (1896, p. 196) and Delf and Michell (1921, p. 118), and as *Halymenia* [sp.] by Delf and Michell (1921, p. 117), with the comment "This species is unnamed but resembles *H. ligulata* [= *Halarachnion ligulatum*]." The species is representative of the genus *Cryptonemia* and will be reported on by Dr. Young-Meng Chiang in his thesis on Cryptonemiaceae.

#### ***Grateloupia filicina* (Wulfen) C. Agardh**

*Grateloupia filicina* (Wulfen) C. Agardh, 1822, p. 223.

*Chaetangium zeyheri* Kützing, 1849, p. 793.

No material of *Chaetangium zeyheri* could be found in Kützing's collection at Leiden. Two of Zeyher's specimens bearing this name are present in the Botanical Museum of Stockholm, and the National Herbarium of Victoria, Australia, also has what probably is an authentic specimen of this species. All these specimens are representative of *Grateloupia filicina* (Wulfen) C. Agardh.

#### ***Grateloupia longifolia* Kylin**

*Grateloupia longifolia* Kylin, 1938, p. 9.

*Schizymenia undulata* (J. Agardh) J. Agardh, 1851a, p. 175 (non *Grateloupia undulata* J. Agardh, 1876, p. 155).

*Platymenia undulata* J. Agardh, 1848, p. 47.

*Platymenia undulata* var. *linearis* J. Agardh, 1849, p. 88.

*Iridaea undulata* sensu Barton, 1893, p. 139.

This species was first described by J. Agardh (1848) as *Platymenia undulata*. Kylin (1938) found it to be a species of *Grateloupia* and named it *G. longifolia*, the epithet *undulata* being unavailable because of the existence of *G. undulata* J. Agardh (1876).

Barton (1893), presumably on the basis of a specimen in Kew Herbarium which was collected in Table Bay by Pappe, reported a plant from South Africa under the name *Iridaea undulata* J. Agardh. As far as I have been able to establish, no species was described under this binomial by J. Agardh or anyone else. The specimen in question is representative of *Grateloupia longifolia* Kylin. Barton, in her list of South African marine algae, also included *Schizy-*

*menia undulata* (J. Agardh) J. Agardh, but she had not seen material of this taxon.

### ***Heterosiphonia crispa* (Suhr) Falkenberg**

*Heterosiphonia crispa* (Suhr) Falkenberg, 1901, p. 642.

*Dasya crispa* Suhr, 1840, p. 279.

*Dasya callithamnion* sensu Barton, 1893, p. 175 [non (Sonder) Harvey = *Heterosiphonia callithamnion* (Sonder) Falkenberg].

On the basis of a specimen collected at Port Elizabeth by Spencer, Barton (1893) reported the occurrence of *Dasya callithamnion* (= *Heterosiphonia callithamnion*) in South Africa. The specimen in question is in the herbarium of the British Museum (Natural History); it is representative of *Heterosiphonia crispa* (Suhr) Falkenberg.

### ***Hypnea musciformis* (Wulfen) Lamouroux**

*Hypnea hamulosa* sensu J. Agardh, 1851b, p. 447; 1876, p. 563.

*Hypnea episcopalis* sensu Barton, 1893, p. 173.

J. Agardh (1851b, 1876) reported *Hypnea hamulosa* from South Africa on the basis of a specimen (Herb. Agardh no. 33796) which he received from Binder. The specimen is representative of *H. musciformis*. In an earlier paper (1958), I have discussed the confusion relating to the binomial *H. hamulosa*.

Barton (1893) reported *Hypnea episcopalis* from South Africa on the basis of a specimen in Dickie's herbarium. This specimen is in the herbarium of the British Museum (Natural History); it is representative of *H. musciformis*.

### ***Kallymenia agardhii* Norris**

*Kallymenia agardhii* Norris, 1964, p. 91.

*Iridaea serratifolia* sensu Barton, 1893, p. 139.

Barton (1893), presumably on the basis of a specimen in Kew Herbarium which was collected in Table Bay by Pappe, reported a plant from South Africa under the name *Iridaea serratifolia* J. Agardh. As far as I have been able to establish, no species was described under this binomial by J. Agardh or anyone else. The specimen in question is representative of *Kallymenia agardhii* Norris.

### ***Metamastophora stelligera* (Endlicher et Diesing) Setchell**

*Metamastophora stelligera* (Endlicher et Diesing) Setchell, 1943, p. 132.

*Melobesia* (*Mastophora*) *stelligera* Endlicher et Diesing, 1845, p. 290.

*Mastophora hypoleuca* Harvey, 1847, p. 108, pl. 41, figs. 1-3.

*Peyssonelia caulescens* Kützing, 1849, p. 694.

The genus *Metamastophora* was erected by Setchell in 1943. He and Suneson (1945) independently came to the conclusion that *Melobesia* (*Mastophora*) *stelligera* Endlicher et Diesing (1845) and *Mastophora hypoleuca* Harvey (1847), both based on material from Port Natal, were conspecific.

Examination of the type of *Peyssonelia caulescens* Kützing (1849), the source of which also was Port Natal (where it was collected by Gueinzus, who also collected Harvey's material of *Mastophora hypoleuca*), has revealed that this taxon also is the same as *Metamastophora stelligera*. The identity of *Peyssonelia caulescens* has been a matter of uncertainty ever since it was erected by Kützing in 1849. The species escaped the notice of J. Agardh and DeToni and was not illustrated by Kützing in his *Tabulae phycologicae*; Barton (1893, p. 142) appears to have been the only person aware of its existence.

***Nienburgia pinnatifida* (Suhr) Papenfuss, comb. nov.**

*Nitophyllum pinnatifidum* Suhr, 1834, p. 726, figs. 7, k and l.

*Nitophyllum kowiensis* Schmitz ex Delf et Michell, 1921, p. 111 (nomen nudum).

In an earlier paper (1956) I pointed out that the long-lost *Nitophyllum serratum* of Suhr (1836) was a species of *Nienburgia* Kylin (1935) and that it was the first species of this genus to have become known from the southern hemisphere. It is of interest, therefore, that another of Suhr's (1834) long-lost species, *Nitophyllum pinnatifidum*, also is representative of *Nienburgia*.

The identity of *Nitophyllum pinnatifidum* has been uncertain ever since it was described. Kützing (1849, p. 869) included it in his list of *Species dubiae*, J. Agardh (1852, p. 672) listed it under *Species inquirendae*, and DeToni (1900, p. 665) placed it under *Species minus notae aut quoad sectionem incertae*.

The National Herbarium of Victoria, Australia, contains a specimen of "*Nitophyllum pinnatifidum* S" from "Algoa-bai", the type locality, which the Director of the Herbarium kindly allowed me to have on loan.

Examination of this specimen revealed that it is the same species as the one to which Schmitz had given the manuscript name of *Nitophyllum kowiensis* (see Delf et Michell, 1921, p. 111) and material of which is present in Tyson's and Becker's collections in the Bolus Herbarium of the University of Cape Town. Dr. Mary A. Pocock collected the plant (her no. 4884) on 18 February 1942 at Port Alfred (Kowie West), where it occurred in the drift as an epiphyte on *Ballia beckeri* Schmitz ex Mazza, and has generously shared her material with me.

***Peyssonelia capensis* Montagne**

*Peyssonelia capensis* Montagne, 1847, p. 177.

*Peyssonelia squamaria* sensu Krauss, 1846, p. 209. Sensu Barton, 1893, p. 142; 1896, p. 197.

*Peyssonelia major* Kützing, 1849, p. 693; 1869, p. 31, pl. 88.

*Ralfsia major* Kützing, 1859, p. 32, pl. 77, fig. iv.

In a previous paper (1952) I pointed out that the South African species that had become well known as *Peyssonelia major* Kützing (1849) should be known as *P. capensis* Montagne (1847).

Krauss (1846) and Barton (1893) reported *Peyssonelia squamaria* from South Africa. The herbarium of the University of Kiel contains one of Krauss's specimens of this species; it is representative of *P. capensis*. Barton (1893, p. 142) cited the record of Krauss and a specimen collected by Gueinzus that she had seen. Later (1896, p. 197) she again named Krauss and Gueinzus as collectors of *Peyssonelia squamaria*, but without an exclamation mark after the name of Gueinzus as she had noted in 1893, and remarked, "I have not seen a specimen of this plant from South Africa, and much doubt if these records are correct." Whereas Barton in 1893 had not seen material of *P. major*, in 1896 she cited, among others, a Gueinzus specimen of this species. It seems reasonably certain that Barton in 1896 removed to *P. major* the Gueinzus specimen that she in 1893 had referred to *P. squamaria*, but neglected to remove his name as a collector of the latter species. Gueinzus was the collector of the type material of *P. major* but was not credited by anyone, except Barton, as a collector of *P. squamaria* in South Africa. The Gueinzus specimen referred to *P. major* by Barton in 1896 is in the herbarium of the British Museum (Natural History); it is representative of *P. capensis*. As far as known, therefore, *P. squamaria* does not occur in South Africa.

The type of the species that Kützing (1859) described as *Ralfsia major* is in the Botanical Museum of Stockholm. It is a specimen of *Peyssonelia capensis*.

### ***Plocamium maxillosum* (Poiret) Lamouroux**

*Plocamium maxillosum* (Poiret) Lamouroux, 1813, p. 138.

*Fucus maxillosus* Poiret, 1808, p. 389.

*Plocamium membranaceum* Suhr, 1840, p. 261.

On the basis of material in the herbarium of Du Petit-Thouars, Poiret in 1808 described a plant from South Africa as *Fucus maxillosus*. The species was transferred to *Plocamium* by Lamouroux when he erected this genus in 1813. C. Agardh (1822, p. 181) reduced *Fucus maxillosus* to a synonym of his variety *costata* (from Australia) of *Delesseria plocamium* [= *Plocamium costatum* (C. Agardh) J. D. Hooker et Harvey] but neglected to include South Africa as one of the localities for this taxon, and Poiret's species has remained buried in the synonymy of *Plocamium costatum* (see DeToni, 1900, p. 597) and lost from the flora of South Africa down to the present. I am indebted to Dr. P. C. Silva for bringing it to my attention.

Examination of a small piece of the type of *Fucus maxillosus*, which was kindly sent to me by Mr. M. Denizot of the cryptogamic herbarium of the Natural History Museum of Paris, has shown that the species is the same as the one described by Suhr in 1840 as *Plocamium membranaceum*. I have seen three of Suhr's specimens: one in Herbarium Agardh (no. 27963), one in the Natural History Museum of Stockholm, and the third in the herbarium of the University of Kiel. The latter is an excellent specimen and is accompanied by extensive notes in Suhr's hand. I have chosen it as lectotype of *P. membranaceum*. *Plocamium membranaceum* or *P. maxillosum*, by which name the plant should be known, is a handsome deep-water species, which is found in the drift in Table Bay and elsewhere on the Cape Peninsula (see also Simons, 1964, p. 185). On the basis of a specimen in Tyson's collection (BOL), Delf and Michell (1921, p. 111) reported it under the name *P. nobile*. On the other hand, the plant from False Bay which Kylin (1938, p. 12) referred to *P. membranaceum* is representative of *P. suhrii* Kützing according to Simons (1964, p. 189). *Plocamium latiusculum* Kützing (1866, p. 17, pl. 47, figs. d-e) was reduced to a synonym of *P. membranaceum* by J. Agardh (1876, p. 341). DeToni (1900, p. 593) and Simons (1964, p. 185) also give *P. latiusculum* as a synonym of *P. membranaceum*, but examination of the type of *P. latiusculum* has shown that this species is conspecific with *P. regidum* Bory (in Bélanger, 1834).

***Polyneura venosa* (Harvey) Papenfuss, comb. nov.**

*Nitophyllum venosum* Harvey, 1847, p. 118.

*Aglaophyllum undulatum* Kützing, 1849, p. 868; 1866, p. 14, pl. 38.

*Nitophyllum undulatum* (Kützing) J. Agardh, 1852, p. 663.

*Myriogramme undulata* (Kützing) Kylin, 1924, p. 59.

*Nitophyllum capense* Harvey in Barton, 1893, p. 144 (nomen nudum).

Examination of the procarp of the plant that Harvey (1847) described from South Africa as *Nitophyllum venosum* has shown that they contain two carpegonial branches and one group of sterile cells. This is a feature that is peculiar to only two genera of Delesseriaceae, namely, *Hemineura* Harvey, a member of the subfamily Delesserioidae, and *Polyneura* (J. Agardh) Kylin, a member of the subfamily Nitophylloideae (see Kylin, 1924, pp. 6 and 33). *Nitophyllum venosum* agrees with species of *Polyneura* not only as regards the structure of the procarp but also in the structure of the thallus; the species is, therefore, here transferred to the genus *Polyneura*.

Examination of Kützing's (1849) material of the South African plant that he described as *Aglaophyllum undulatum* and of a Harvey specimen in the herbarium of the British Museum (Natural History) of the plant that Barton (1893)

reported as *Nitophyllum capense* Harvey, a nomen nudum, has shown that these names are based on specimens of *Polyneura venosa*.

The occurrence in South Africa of a species of *Polyneura* presents an interesting extension of the geographic distribution of this genus. Heretofore, *Polyneura* has been credited with four species (see Kylin, 1924), three of which are based on types from England and the fourth on a type from Vancouver Island in the northeastern Pacific.

### **Polysiphonia incompta** Harvey

*Polysiphonia incompta* Harvey, 1847, p. 44.

*Polysiphonia sertularioides* sensu Barton, 1896, p. 198. Delf and Michell, 1921, p. 113.

*Polysiphonia urceolata* sensu Delf and Michell, 1921, p. 113.

Barton (1896) and Delf and Michell (1921) reported *Polysiphonia sertularioides* from South Africa. Barton saw material collected at Port Elizabeth by Farquhar and in British Kaffraria by Flanagan, and Delf and Michell saw duplicates of the Flanagan material reported on by Barton and also material collected by Flanagan at Cape Morgan. The specimens reported on by Barton are in the herbarium of the British Museum (Natural History) and those reported on by Delf and Michell are in the Bolus Herbarium of the University of Cape Town. All these specimens are representative of *P. incompta*. As far as known, therefore, *P. sertularioides* does not occur in South Africa.

*Polysiphonia urceolata* was reported from South Africa by Barton (1893, p. 176) and by Delf and Michell (1921, p. 113). Elsewhere in the present article it is pointed out that Barton's record is based on a specimen of *P. sulcata*. The specimens from Algoa Bay reported as *P. urceolata* by Delf and Michell are in the Bolus Herbarium; they are representative of *P. incompta*. As far as known, therefore, *P. urceolata*, like *P. sertularioides*, does not occur in South Africa.

### **Polysiphonia sulcata** Rudolphi

*Polysiphonia sulcata* Rudolphi, 1831, p. 177.

*Polysiphonia pappeana* Kützinger, 1849, p. 813; 1863, p. 17, pl. 55, figs. f-h.

*Polysiphonia linocladia* Kützinger, 1849, p. 813; 1863, p. 18, pl. 56, figs. a-e.

*Polysiphonia juncea* Kützinger, 1849, p. 813; 1863, p. 17, pl. 55, figs. a-e.

*Polysiphonia urceolata* sensu Barton, 1893, p. 176.

*Polysiphonia sulcata*, which is based on a plant from Table Bay, has suffered neglect ever since its establishment by Rudolphi in 1831. Suhr (1834, p. 741) appears to be the only person who accepted it. The name is not mentioned, even as a synonym, in the works of J. Agardh and DeToni. Kützinger (1849,

p. 811) included it in the synonymy of *P. agardhiana* Greville, without, however, listing South Africa as one of the localities of this species. *Polysiphonia sulcata* is a sparsely branched flagelliform plant which is common in Table Bay. Kützing (1849) described it under three different names (*P. pappeana*, *P. linocladia*, and *P. juncea*) on specimens given to him by Pappe. His types are at Leiden, where I have seen them.

Barton's (1893) record of *Polysiphonia urceolata* from Table Bay is based on a misidentification of a Harvey specimen of *P. sulcata* which is in the herbarium of the British Museum (Natural History).

Authentic material of *Polysiphonia sulcata* is present in the following institutions: Natural History Museum of Vienna, Natural History Museum of Stockholm, Rijksherbarium in Leiden, National Herbarium of Victoria in Melbourne, and the Botanical Institute of Kiel University. I have chosen a sheet (which contains four mounts of the species) in the Natural History Museum of Stockholm as lectotype of the species.

#### ***Polysiphonia urbana* Harvey**

*Polysiphonia urbana* Harvey, 1847, p. 55.

*Polysiphonia corymbosa* sensu Delf and Michell, 1921, p. 114.

*Polysiphonia corymbifera* sensu Delf and Michell, 1921, p. 114.

The only record of the occurrence of *Polysiphonia corymbosa* in South Africa is that by Delf and Michell (1921). This record and the one of *P. corymbifera* by the same authors are based on the same material, which is in the Bolus Herbarium of the University of Cape Town. These specimens (3) are representative of *P. urbana*. As far as known *P. corymbosa* does not occur in South Africa. The South African species previously known as *P. corymbifera* (C. Agardh) Harvey is now known as *Strebloladia corymbifera* (C. Agardh) Kylin (1938).

#### ***Prionitis filiformis* Kylin**

This species of Kylin's (1941, p. 13; also see Smith, 1944, p. 244, pl. 56, fig. 1) is based on a plant from California which Harvey (1853, p. 197) first described under the name *Prionitis lanceolata*  $\beta$  *angusta* [not *P. angusta* (Harvey) Okamura = *Carpopeltis angusta* (Harvey) Okamura].

*Prionitis filiformis* is here reported for the first time from South Africa. Dr. Pocock and I obtained specimens of it in the drift at Port Alfred in June and July of 1938, and she collected attached plants of it at Riet River on 17 August 1943 (her nos. 7501, 7502 and 7503). Dr. Pocock also found it in the drift at Kleinmond (east of Port Alfred) on 8 August 1947 (her no. 9097).

It is surprising that *Prionitis filiformis* should occur in South Africa. Considering how far apart California and South Africa are, it is logical to presume

that the South African plant would be a different species. However, comparison of South African specimens with ones from California has not brought to light clear-cut characters whereby they may be distinguished.

***Pseudogloiophloea capensis* (Setchell) Levring in Svedelius**

*Pseudogloiophloea capensis* (Setchell) Levring in Svedelius, 1956, p. 13, figs. 6, 7, 9–14.

*Gloiophloea capensis* Setchell, 1914, p. 117, pl. 16, figs. 58 and 59.

*Scinaia furcellata* sensu Barton, 1893, p. 144. Sensu Delf and Michell, 1921, p. 102.

*Halymenia furcellata* sensu Harvey, 1841, p. 52 (pro parte, i.e. as to specimens from South Africa).

Levring (1953, p. 505; 1955, p. 420; and in Svedelius, 1956, p. 8) has pointed out that Setchell (1914) had the wrong plant in hand when he studied what he thought was *Gloiophloea scinaoides*, the type of the genus, and that none of the species referred to *Gloiophloea* by him belongs to this genus. Instead, the species described by Setchell belong to a new genus, for which Levring proposed the name *Pseudogloiophloea*.<sup>2</sup>

The type of *Pseudogloiophloea capensis* was collected by Davy at Port Alfred and is in the herbarium of the University of California. The records of Barton (1893) and of Delf and Michell (1921) of *Scinaia furcellata* (a species which does not occur in South Africa, as far as known) are based on *P. capensis*, as is the record of Harvey (1841) of *Halymenia furcellata*. The specimen cited by Barton is in the herbarium of the British Museum (Natural History), those cited by Delf and Michell are in the Tyson Collection of the Bolus Herbarium, and the specimens (from Table Bay) on which Harvey's record is based are in his herbarium at Trinity College, Dublin.

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<sup>2</sup> Subsequent to the appearance of Setchell's paper and prior to the appearance of Levring's papers, four new species of *Gloiophloea* were described, as follows: *G. fascicularis* Børgesen (1934, p. 2), *G. chinensis* Tseng (1941, p. 111), *G. caribaea* Taylor (1943, p. 148), and *G. verae* Dickinson (1951, p. 295). *G. fascicularis* Børgesen has been removed to *Pseudogloiophloea* by Desikachary and Singh (1958). Taylor (1943, p. 149), when describing *G. caribaea*, remarked that this species comes close to *G. halliae* Setchell (which is also based on a plant from the Caribbean). Until more has become known about the range in variation in these two taxa, it seems best not to transfer *G. caribaea* to *Pseudogloiophloea* as an autonomous species. The figures by Tseng (1941, figs. 13a and b) and Dickinson (1951, fig. [3]) of *G. chinensis* and *G. verae*, respectively, show that these two species are representative of the genus *Pseudogloiophloea*, and this has been confirmed by examination of specimens of these two species in the herbarium of the University of California (isotype of *G. chinensis* and material of *G. verae* collected by my son, T. Papenfuss, 1 mile east of Tema, Ghana, in November 1961). The following new combinations are, therefore, in order:

***Pseudogloiophloea chinensis*** (Tseng) Papenfuss, comb. nov. *Gloiophloea chinensis* Tseng, 1941, p. 111, fig. 13, pl. 10.

***Pseudogloiophloea verae*** (Dickinson) Papenfuss, comb. nov. *Gloiophloea verae* Dickinson, 1951, p. 295, fig. [3], pl. 4.



Harvey (1846, text to pl. 69) gave *Coralloopsis dichotoma* Suhr (1839, p. 70, pl. 3, fig. 44) as a synonym of *Ginnania furcellata* (i.e. *Pseudogloiophloea capensis*, as far as Harvey's record from the Cape of Good Hope is concerned). However, as I have pointed out in an earlier paper (1956, p. 70), *C. dichotoma* Suhr is representative of *Galaxaura magna* Kjellman (1900).

Setchell was of the opinion that *Pseudogloiophloea capensis* is dioecious. However, the species is monoecious, as has been pointed out by Svedelius.

### ***Rhabdonia natalensis* Reinbold**

*Rhabdonia natalensis* Reinbold, in Tyson, 1912, p. 199. Delf and Michell, 1921, p. 107

*Solieria natalensis* (Reinbold) Borgesen, 1943, p. 40 (only as to binomial, not as to material in hand).

This species was described by Reinbold (in Tyson, 1912) on the basis of material collected by Flanagan (his no. 278) near Cape Morgan and by Becker at The Kowie (Port Alfred). Reinbold did not designate a type. I have chosen one of his specimens in the Munich herbarium as lectotype of the species. This specimen was collected by Becker and is labelled "Rhabdonia natalensis Reinb." in Reinbold's hand. Becker's collection in the Bolus Herbarium contains an isotype of the species and the Tyson Collection of the Bolus Herbarium contains a duplicate of Flanagan no. 278.

Borgesen (1943), on the basis of material from Mauritius, made the combination *Solieria natalensis*. However, the South African plant is not a species of *Solieria*, which genus includes species that are multiaxial in construction. To judge from Borgesen's illustration of the plant from Mauritius (his fig. 14), it can be stated with reasonable certainty that it is not representative of *Rhabdonia natalensis*, but where it belongs taxonomically, I am unable to say. The South African plant, which is uniaxial in construction, appears to be correctly placed in *Rhabdonia*.

### ***Spyridia hypnoides* (Bory) Papenfuss, comb. nov.**

*Thamnophora hypnoides* Bory in Bélanger, 1834, p. 175.

*Spyridia insignis* (J. Agardh) J. Agardh, 1851b, p. 344.

*Bindera insignis* J. Agardh, 1841, p. 37.

*Spyridia ericoides* (Hering) Kützinger, 1847, p. 37.

*Alsidium ericoides* Hering, 1841, p. 91.

*Spyridia tetracantha* Kützinger, 1862, p. 16, pl. 52, figs. d and e.

*Spyridea aculeata* (C. Agardh ex Decaisne) Kützinger, 1843, p. 377; 1849, p. 668.

*Ceramium aculeatum* C. Agardh ex Decaisne, 1841, p. 179.

On the basis of material collected by Krauss in South Africa, Hering in 1841 described a plant as *Alsidium ericoides*. This species was removed to

*Spyridia* by Kützing in 1847. J. Agardh in 1851(b) reduced *S. ericoides* to a synonym of *S. insignis* (J. Agardh). J. Agardh, a species based on material from India. To judge from the references cited by J. Agardh (1851b, p. 345) and DeToni (1903, p. 1434) the erroneous impression is gained that the name *S. ericoides* has the right to priority. J. Agardh (loc. cit.) in error cited his "Adversaria" (1844) as the place of publication of *S. insignis*. In this work the species (as *Bindera insignis*) is mentioned on page 29, but the name is not accompanied by a description. However, the species was described by J. Agardh in 1841 (as *Bindera insignis*, a combined generic and specific description). The part of J. Agardh's 1841 paper which included the description of *B. insignis* appeared in Heft 1 of volume 15 of *Linnaea* and probably appeared in the early part of 1841. Hering's paper (1841) in which he described *Alsidium ericoides* appeared in the October issue of volume 8 of the *Annals and Magazine of Natural History*. Another name given to this species, *Ceramium aculeatum* C. Agardh ex Decaisne (discussed below), was also published in 1841. The month of appearance of Decaisne's paper is not known. However, as is pointed out below, the oldest name for this species is *Thamnophora hypnoides* Bory (in Bélanger, 1834).

I have examined J. Agardh's type (no. 51511) of *Bindera insignis* and original material of *Alsidium ericoides* in the herbaria of the Natural History Museum of Vienna (lectotype) and the Botanical Institute of the University of Kiel and agree with the opinion of J. Agardh that these two taxa are conspecific. I have also examined Kützing's (1862) type (a fragment) of *Spyridia tetracantha*, a species based on material from South Africa, and have found that it also is representative of *S. insignis*, a conclusion previously arrived at by J. Agardh (1876, p. 272), presumably on the basis of Kützing's figures of the former.

In connection with the study of *Spyridia insignis* my attention was also drawn to *S. aculeata* (C. Agardh ex Decaisne) Kützing. This species was described by Decaisne (1841, p. 179) as *Ceramium aculeatum* on the basis of material collected by Schimper at Nuweiba (Sinai Peninsula) in the Red Sea. It was removed to *Spyridia* by Kützing in 1843. Kützing at the same time reduced *Bindera insignis* J. Agardh to a synonym of *S. aculeata*. Ruprecht (1849, p. 79) referred to the Red Sea plant as "*Bindera* sp. an *insignis*." Durairatnam (1961), in reporting both *S. aculeata* and *S. insignis* from Ceylon, remarked (p. 68): "I was not able to observe much difference between *Spyridia insignis* J. Ag. and *Spyridia aculeata* (Schimp.) Kuetz. except in external appearance." This apparent uncertainty about the distinctness of these two taxa and the fortunate circumstance that the herbarium of the University of California contains an isotype of *S. aculeata* (Schimper, *Unio itineraria* no. 966) caused me to compare *S. aculeata* with *S. insignis*. I could find no difference between them and consider them to be representative of the same species.

Finally, another species that required looking into was the one described by Bory (in Bélanger) as *Thamnophora hypnoides* in 1834 from Cape Comorin in southern India. J. Agardh (1851b, p. 345) gave this name as a doubtful synonym of *Spyridia insignis* and it has remained in that uncertain position down to the present.<sup>3</sup>

At my request Dr. Bourrelly and Mr. Denizot kindly sent me a small piece of the type of *T. hypnoides*, which is in the cryptogamic herbarium of the Natural History Museum of Paris. Examination of this piece has shown that *T. hypnoides* is conspecific with *Spyridia insignis*. Since the specific name *hypnoides* is the oldest of those given to this species, it becomes necessary to make the new combination *S. hypnoides*.

### ***Thamnoclonium proliferum* Sonder**

*Thamnoclonium proliferum* Sonder, 1845 (January), p. 56. Barton, 1896, p. 459.

*Thamnoclonium latifrons* Endlicher et Diesing, 1845 (April), p. 289.

*Thamnoclonium hirsutum*  $\beta$  *africanum* Kützing, 1849, p. 794.

*Thamnoclonium dichotomum* sensu Mazza (?), 1915, p. 61.

The genus *Thamnoclonium* was erected by Kützing in 1843 on the single Australian species *T. hirsutum* Kützing. Both Kützing (1849, p. 794) and J. Agardh (1876, p. 179) later recognized that this species was the same as the one from Australia described by J. Agardh in 1841 as *Polyphacum dichotomum*. The correct name of this species is, therefore, *T. dichotomum* (J. Agardh) J. Agardh.

In 1845 Endlicher and Diesing described *Thamnoclonium latifrons* on the basis of material from South Africa and Sonder described *T. proliferum* on the basis of material from Australia. In 1849 Kützing described *T. hirsutum*  $\beta$  *africanum* on the basis of material from South Africa.

Examination of Australian material of *Thamnoclonium proliferum* and of the types of *T. latifrons* (in the herbarium of the Museum of Natural History of Vienna) and *T. hirsutum*  $\beta$  *africanum* (in the Rijksherbarium, Leiden) has convinced me that these names apply to the same taxon, *T. proliferum* Sonder. Barton (1896, p. 459) reported *T. proliferum* from South Africa. The specimen in question, "ex Herb. Lübeck", is in the herbarium of the British Museum (Natural History), where I have seen it.

I have not seen the South African material referred to *Thamnoclonium dichotomum* by Mazza (1915) but suspect it to be representative of *T. proliferum*. It should be mentioned, however, that *T. dichotomum* and *T. proliferum* appear to be very similar, to judge from published descriptions of the two species. If they should in the future be shown to be conspecific, the correct name of the species will be *T. dichotomum* (J. Agardh) J. Agardh.

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<sup>3</sup> DeToni (1903, pp. 1433 and 1434) includes *Thamnophora hypnoides* in the synonymy of both *Spyridia aculeata* and *S. insignis*.

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# A NEW EUPHORBIA FROM TANZANIA†

L. C. LEACH

## *Euphorbia proballyana* Leach, sp. nov.

*E. quadrangulari* Pax affinis sed habitu ramosissimo, statura brevior; podariis latissimis robustioribus haud confluentibus; pedunculo brevior plerumque 3-bracteato; involucro, capsula et semine omnibus minoribus differt; a *E. contorta* Leach habitu ramosissimo, ramis quadrangularibus; foliis minimis; pedunculo plerumque 3-bracteato statim dignoscenda; ad *E. waterbergensem* R. A. Dyer ordinatione inflorescentiae accedit sed habitu ramosiore, ramis quadrangularibus; podariis haud confluentibus; capsula sessili ovoidea; stylis libris e basi; semine verrucoso et characteris ceteris facile distinguenda.

*Frutex* succulentus, ferociter armatus, dense ramosus, vertice applanatus, ad 1·3 m altus (plerumque minor quam 1 m); ramis ramulisque divaricatis, verticillatim dispositis, segmentorum ex marginibus basi versus producti. *Rami* et *ramuli* robusti, 4-angulati, leviter constricti, saepe spurie articulati; *segmentis* 6—20 cm longis, 1—3 cm crassis (plerumque c. 2 cm); faciebus lateralibus subparallelis, plus minusve planis; *marginibus* sinuato-dentatis, dentibus ad 3 mm altis. *Podaria* plus minusve anguste obovata, parum truncata, late decurrentia, haud confluentia, 8—12 mm longa, 3—4 mm lata, pallide brunnea fusco-marginata mox cinerascens. *Spinae* binae, 8—10 mm longae (segmentorum prope basin breviores) regulariter dispositae 10—14 mm secus angulos distantes, horizontaliter patulae, ad angulum 90°—120° divergentes, cineracae apicem versus nigrescens. *Folia* exigua confestim cadentia; cicatricibus spinula aciculari in quoque latere munitis. *Inflorescentiae* ex axillis tuberculorum secus angulos segmentorum ultimorum exilientes; *cyathia* 3—4 (5) (plerumque 4, perrariter 5); cyathio medio masculino deciduo; cyathiis ceteris bisexualibus, lateraliter et abaxialiter dispositis (cyathio adaxiali adjecto ubi cyathiis 5). *Pedunculus* rudimentalis, plerumque 3-bracteatus; *bracteae* plus minusve ovatae, squamiformes, c. 1 mm longae, 1·5 mm latae; *cymarum rami*, brevissimi, c. 1 mm longi; *bracteae* subquadratae, obtusae vel truncatae, interdum emarginatae, irregulariter denticulatae, c. 1·75 mm longae. *Involucrum* glabrum, crateriforme vel plus minusve obconicum, c. 3 mm longum, 3·5 mm diam. glandulis inclusis

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(perrariter ad 4.5 mm), rubro-purpureum, obscure albescenti-punctatum; *glandulis* 5, anguste transverse oblongo-ellipticis, 2—2.5 mm  $\times$  0.6—0.75 mm (perrariter 2.5 mm  $\times$  1.25 mm), plerumque suberectis (perrariter patulis) leviter concavis vel planis, arcte contiguis, minute tuberculato-punctulatis, obscure rubro-croceis; *lobis* 5, obovatis, irregulariter dentato-fimbriatis purpureis. *Flores masculi* 15—20, 5-fasciculati, bracteolis fimbriatis; bracteae fasciculares lobulatae, fimbriatae; *pedicelli* 2.5 mm longi, albi; *filamenta* c. 0.6 mm longa, magentea; *antherae* persicinae, polline aureo. *Ovarium* trigono-oblongum, sessile; *styli* graciles, c. 1.5 mm longi, libri fere e basi, rosei, apicibus emarginatis eburneis. *Capsula* 3-lobata, lobis plus minusve ovoideis, sessilibus, perianthio rudimentali, c. 3.5 mm longa, ad 4 mm diam. rubra, obscure albescenti-punctata, apice fusco-purpurascens. *Semen* ovoideum, c. 1.8 mm  $\times$  1.5 mm, verrucosum, brunneum, verrucis aliquot pallidis.

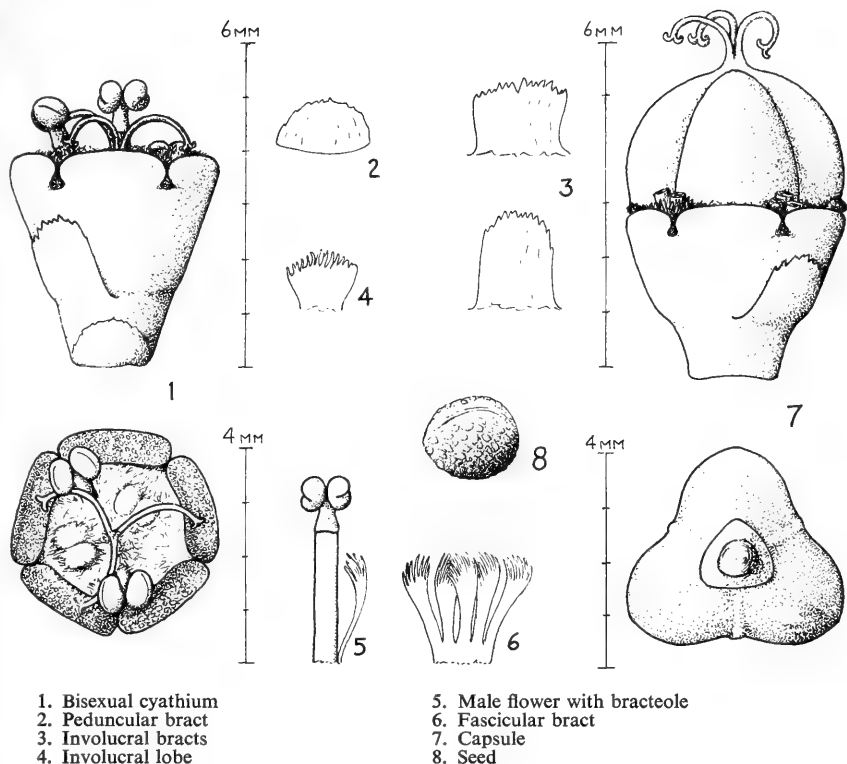
Type: *Leach & Brunton* 10138 (BR; EA; G; K; LISC; PRE, holotype; SRGH; ZSS).

TANZANIA. Central Prov., Kilosa Distr., Great Ruaha Gorge, prope Malolo, cult. Nairobi, *Harris* s.n. in *Bally* E238 (PRE, photo.);  $\pm$  30 mls. W Mikumi, c. 36° 35' E; 7° 30' S, cult. Salisbury & Nelspruit, fl. & fr. *Leach & Brunton* 10138 (BR; EA; G; K; LISC; PRE; SRGH; ZSS); Lukose Riv., st. *Leach & Brunton* 10132 (PRE).

*E. proballyana* appears to be rather rare, with its known distribution restricted to the Great Ruaha Gorge in Central Tanzania. At the type locality, at an altitude of  $\pm$  2250', the steep stony slopes of the gorge support a typically xerophytic vegetation, with *Adansonia digitata* L., *Euphorbia quadrialata* Pax, *E. sp. cf. E. ussanguensis* N. E. Brown, *E. candelabrum* Trém. ex Kotschy, *Monadenium spinescens* (Pax) Bally, *M. sp. cf. M. echinulatum* Stapf, *Caralluma schweinfurthii* Berger, *Echidnopsis* sp., *Sansevieria* spp. and *Aloe* spp.

It seems probable that the low shrubby plant collected by Goetze (No. 463), in the same gorge in 1899, depicted in Goetze & Engler, *Veget. Deutsch Ostafri.*: Pl. 15 (1902), is identical with our new species. Unfortunately all Goetze's specimens have been destroyed and there is some confusion regarding his three gatherings of *Euphorbia* from this locality (Goetze 463, 464 & 465).

Clearly the name *E. stuhlmannii* Schweinfurth ex Volken's cannot be applied to any of the trees shewn in Plates 13—16 (*tom. cit.*), these being recognisable, in all probability, as *E. quadrialata* and *E. sp. cf. E. ussanguensis*, both mentioned above as known to be associated with the new species. While it might be reasonable, in view of its height and habit, to identify the low shrub (Pl. 15) as *E. stuhlmannii*, it is thought, at least on grounds of locality, to be far more probable that this represents *E. proballyana*.

FIG. 1. *E. proballyana* Leach.

It should, perhaps, be mentioned that Schweinfurth's use of the epithet *stuhlmannii* was predated by Pax' use, in 1897, of the same name for a perennial herb from East Africa, and that Volkens' description seems exactly to match that of *E. heterochroma* Pax.

Another name which had to be considered was that of *E. confertiflora* Volkens, the type of which, *Holst* 8821, has also been destroyed. The description is rather difficult of interpretation but certain characters would seem to preclude the possibility of this plant being identical with the new species; namely: cyathia always 3; involucre plate-shaped on top, 6 mm diam.; ovary with a style pillar on top with the 3 style branches forked in the upper third. Moreover this species also is considered probably to be conspecific with *E. heterochroma* Pax. The only character not in accord with that species is the sessile ovary, but

there are several indications that the cyathia described were at an immature stage, which could easily account for this apparent discrepancy; certainly the distribution given by Volken's coincides with that of *E. heterochroma*.

It is with great pleasure that this most distinctive new species is named for Mr. Peter R. O. Bally, who has contributed so much to our knowledge of the succulent plants of tropical East Africa, and who is so well known, not only for his magnificent monographic work "The genus *Monadenium*", but for numerous publications and particularly for many exquisite drawings and watercolours of succulent plants.

*E. proballyana* is possibly the most distinct of the large, complex, and often exasperating group of closely related species which includes *E. quadrangularis* Pax and *E. contorta* Leach; from both of these it is easily separated by its more ramose habit, and particularly by its 3-bracteate peduncle, which bears a cyme of 3—5 cyathia; from the former there are additional differences in the lower stature, the more robust broadly decurrent separate spine shields and the smaller involucre, capsule and seed of the new species; while from the latter it may immediately be distinguished by its 4-angled branches and much smaller leaves.

In the arrangement of the inflorescence there is superficially an affinity with *E. waterbergensis* R. A. Dyer, but the relationship is, in fact, not particularly close, as this Transvaal species with its 4—6-angled branches, continuous spine shields, stipitate capsules and smooth seeds, falls into the *E. griseola* Pax complex rather than into the group containing *E. quadrangularis*.



*Euphorbia proballyana* Leach

Portion of a branch from a plant cultivated at Salisbury, shewing cymes with 4 cyathia.

*Plant*: a succulent, fiercely armed, densely branched, rather flat-topped compact shrub, up to c. 1.3 m high (usually less than 1 m), up to 1.5 m or more diam. *Branches* and *branchlets* divaricately, more or less verticillately branched and rebranched from the margins from near the base of the segments, robust, 4-angled, (abnormally 5-angled, then spirally twisted), not much constricted, often pseudo-articulated; *segments* 6—20 cm long, 1—3 cm thick (usually c. 2 cm), more or less parallel sided, with the lateral faces more or less flat; with the margins sinuate toothed, with the teeth up to 3 mm high. *Spine shields* narrowly obovate, somewhat truncate at the apex, broadly decurrent, neither confluent nor enclosing the flowering eye, 8—12 mm long, 3—4 mm wide, pale brown with darker margins, soon becoming grey. *Spines* 8—10 mm long (shorter towards the base of the segments), grey, blackish towards the apex, in regularly spaced pairs, 10—14 mm apart along the angles, horizontally spreading, diverging at an angle of 90°—120°. *Leaves* exiguous, almost immediately caducous, with a pair of sharp prickles, 0.5—1 mm long, flanking the obscure leaf scar. *Inflorescence* in solitary axillary cymes along the length of the ultimate segments; *cyathia* 3—4 (usually 4, very rarely 5), with the central primary cyathium male deciduous, and the bisexual cyathia arranged laterally and abaxially (plus an additional adaxial cyathium when 5 are produced). *Peduncle* rudimentary, usually 3-bracteate (probably 4-bracteate when there are 5 cyathia); *bracts* more or less ovate, scale-like, c. 1 mm long, 1.5 mm wide; *cyme branches* very short, c. 1 mm long; *bracts* subquadrate, obtuse or truncate, sometimes emarginate, irregularly denticulate, c. 1.75 mm long. *Involucre* glabrous, cup-shaped or obconic, c. 3 mm long, c. 3.5 mm diam. including the glands (very rarely up to 4.5 mm), purplish red, minutely white dotted; *glands* 5, narrowly transversely oblong-elliptic, 2—2.5 × 0.6—0.75 mm (very rarely 2.5 mm × 1.25 mm), usually suberect (very rarely spreading), slightly concave or flat, closely contiguous, minutely tuberculate punctate, dull reddish orange or dark orange; *lobes* 5, obovate, irregularly dentate fimbriate, purplish red. *Male flowers* 15—20, in 5 fascicles with fimbriate bracteoles; *fascicular bracts* lobulate, fimbriate; *pedicels* 2.5 mm long, whitish; *filaments* c. 0.6 mm long, magenta pink; *anthers* pale peach coloured, with bright yellow pollen. *Ovary* oblong, trigonous, sessile; *ovule* attached under a minutely fringed small hood; *styles* slender, c. 1.5 mm long, free almost or quite to the base, pink, with shortly bifid or emarginate whitish apices. *Capsule* 3-lobed, with the lobes more or less ovoid, c. 3.5 mm long, 3.5—4 mm diam., sessile, seated on a rudimentary rim-like perianth, red, becoming dark purple at the apex, mottled with minute whitish dots. *Seed* ovoid, c. 1.8 mm × 1.5 mm, dark brown, verrucose, with some verrucae pale creamy brown, suture blackish brown.

## ACKNOWLEDGEMENTS

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Dr. W. J. Louw, for conducting me to the locality in the Waterberg District where fruiting material of *E. waterbergensis* was collected.

# OBSERVATIONS ON THE ULTRASTRUCTURE OF CHROMOPLASTS IN *CELASTRUS SCANDENS*\*†

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## ABSTRACT

The structure of chromoplasts in the aril of ripe fruit of *Celastrus scandens* was studied with the electron microscope. A remarkable regularity was observed in respect of shape and internal structure. Pigments were associated with large spindle-shaped bodies analogous to grana in chloroplasts and which were interconnected by striated, fibre-like filaments. It is suggested that chromoplasts may arise from proplastids directly and not necessarily by unidirectional ontogenesis from chloroplasts or leucoplasts.

## INTRODUCTION

Investigations of the ultrastructural anatomy of plastid organelles have been devoted almost exclusively to chloroplasts, and only in comparatively recent years have contributions been concerned with the chromoplast (e.g. Frey-Wyssling and Kreutzer, 1958; Thomson, 1965; Kirk and Juniper, 1967.) Perhaps this may be ascribed to the relatively minor position in the hierarchy of plastid ontogeny to which the chromoplast has been relegated: a monotropic development is assumed from initials through proplastids and leucoplasts, with an irreversible ontogenesis from chloroplast to chromoplast (Frey-Wyssling and Mühlethaler, 1965.) Alternately, compared with chloroplasts, chromoplasts appear to be somewhat functionless organelles.

## MATERIALS AND METHODS

Epidermal peels, stripped from the crimson aril of *Celastrus scandens* at the stage of opening of the enclosing loculicidally dehiscent orange capsules, were fixed in glutaraldehyde, 3% with respect to 0.05 M phosphate buffer, pH 6.8. The tissue was then postfixed in 2% osmium tetroxide ( $\text{OsO}_4$ ) and prepared for electron microscopy by dehydration, infiltration with and embed-

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ment in a plastic mixture, and thin-sectioning. Sections were not stained prior to viewing in the electron microscope.

Separate pigment extractions were made of the arils and the enclosing capsules according to the method described by Kirk and Juniper (1967) and their respective absorption spectra determined spectrophotometrically.

#### RESULTS AND DISCUSSION

The cells of the epidermal and cortical tissues of the aril contain numerous (from a few to 20 and more), long (up to  $30\mu$ ) lanceolate to acicular chromoplasts. These organelles are the most conspicuous feature of the cells (Fig. 1, C.) Figure 2, which is a low-magnification electron micrograph, shows the cells as being highly vacuolated (V) with chromoplasts (C), mitochondria and nuclei (N) in a cytoplasm (CY) parietally appressed against the cell walls. The protoplasts of adjoining cells are interconnected through prominent plasmodesmata (P). Except for their unusual length and the apparent disarray of the grana-fretwork system there is, at this magnification, little morphological distinction between chromoplasts and chloroplasts.

The probable direct ontogeny of chromoplasts in *Celastrus* from proplastids is supported by Fig. 3. A prolamellar body (PB) is identified in a differentiating proplastid—in this case a prochromoplastid since there is no evidence of chloroplasts in the tissue at this stage of fruit development. At a higher magnification (Fig. 4) the double membrane (DM) is in evidence. Numerous osmiophilic homogeneous globuli (OG), probably indicative of the advanced state of liphanerosis (Frey-Wyssling and Mühlethaler, 1965), are scattered throughout the plastid.

Yellow, carotenoid-containing structures, circular in transverse section, may be observed in the chromoplasts of ripening *Celastrus* fruits. These are here termed spindle-shaped bodies (SB), and appear equivalent to the spindle-shaped bodies and swellings on fibres in *Capsicum* described by Frey-Wyssling and Mühlethaler (1965) and Kirk and Juniper (1967), respectively.

Figure 5 shows the elongated nature of the chromoplast and, as compared with chloroplasts, the rather disorganised lamellar system. The spindle-shaped bodies (Fig. 6, in longisection; Fig. 7, in cross-section) have the appearance of dilated grana. They are interconnected by thin, striated, fibre-like filaments (F),

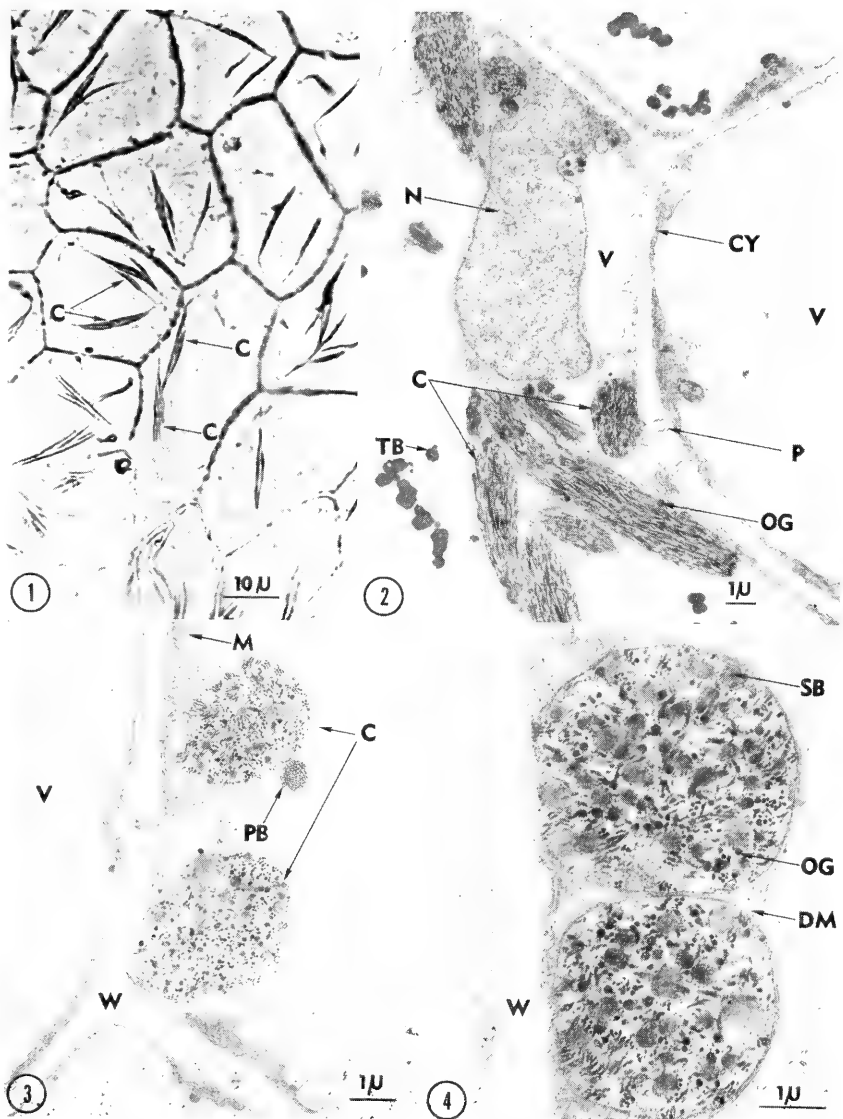
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#### FIGS. 1—4: Chromoplasts in *Celastrus scandens*.

FIG. 1: Photomicrograph showing lanceolate to acicular shape of chromoplasts in sub-epidermal cells of aril. Mounted in glycerin.

FIGS. 2—4: Electron micrographs at increasing magnifications. C, chromoplast; CY, cytoplasm; DM, double membrane; M, mitochondrion; N, nucleus; OG, osmiophilic globule; P, plasmodesmata; PB, prolamellar body; SB, spindle-shaped body; TB, tannin body; V, vacuole; W, cell wall.





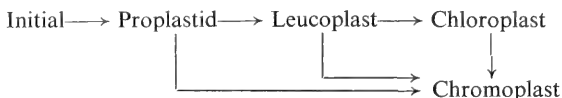
frequently forming dense filament packets (FP). The spindle-shaped bodies have diameters of up to  $300\text{ }\mu\text{m}$  as compared with  $100\text{ }\mu\text{m}$  of equivalent structures (swellings on fibres) in *Capsicum* (Kirk and Juniper, 1967). The osmiophilic globuli with diameters of up to  $85\text{ }\mu\text{m}$ , are rarely found within the spindle-shaped bodies; they appear to occur between them. The filament packets of the fibre-like filaments appear to be osmiophilic but it is doubted whether in fact they are the osmiophilic globuli. Rather, they appear to be concentrations of lamellae high in lipid content. The stroma (S) appears to have lost its granularity.

The absorption spectra of the carotenoid pigments extracted from arils and capsules in hexane are shown in Fig. 8.

The spectra are quite similar with the capsules having somewhat less carotenoids than the arils. Complete chromatographic separation and determination of the pigment components is not reported here. Absorption maxima of approximately 443 and 470, and 447 and 474  $\text{m}\mu$  for yellow and red fruits of *Capsicum* respectively, have been reported by Kirk and Juniper (1967).

#### CONCLUSIONS

The results of this investigation—which is limited in that only fully ripe fruits were used—show a number of similarities and differences with those previously reported. The chromoplasts maintain a remarkable regularity in shape in contrast to those in Navel oranges (Thomson, 1965). The ontogeny of the pigment bodies, although not followed sequentially, appears to correspond to Frey-Wyssling's and Kreutzer's (1958) *Capsicum* type, that is, culminating with the development of spindle-shaped bodies. Although ontogenesis from leucoplasts and/or chloroplasts is not excluded, the chromoplasts in *Celastrus* probably also arise from proplastids directly:



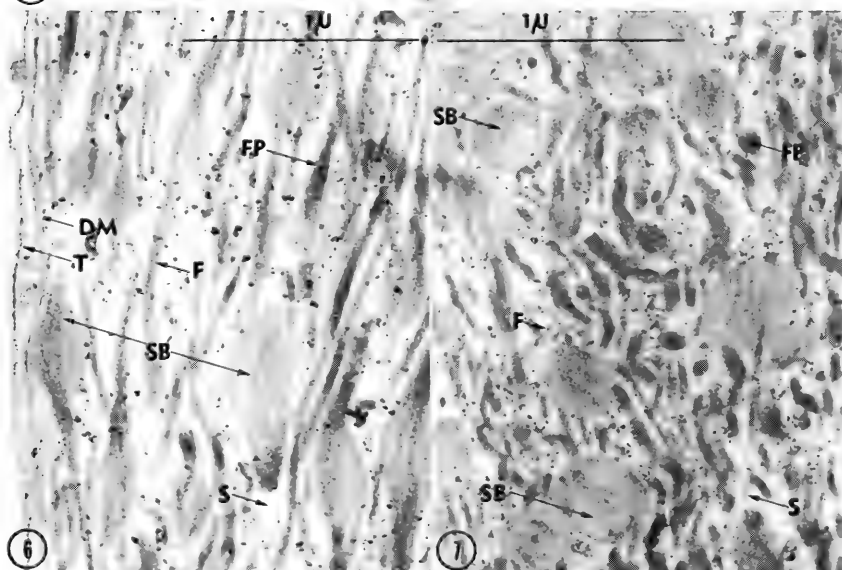
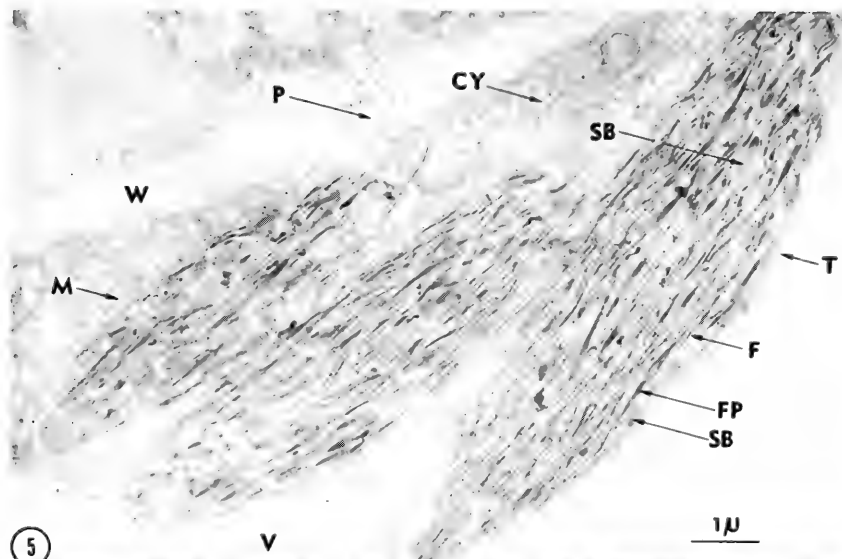
In order to determine whether this is the case an ontogenetic study of chromoplasts in the developing fruit coupled with an analysis of the carotenoids is under way.

FIGS. 5—7: Electron micrographs of chromoplasts.

FIG. 5: Organisation of spindle-shaped bodies and lamellar system.

FIG. 6: High magnification in longisection.

FIG. 7: High magnification in transverse section. CY, cytoplasm; DM, double membrane; F, filament; FP, filament packets; M, mitochondrion; P, plasmodesmata; S, stroma; SB, spindle-shaped body; T, tonoplast; V, vacuole; W, cell wall.



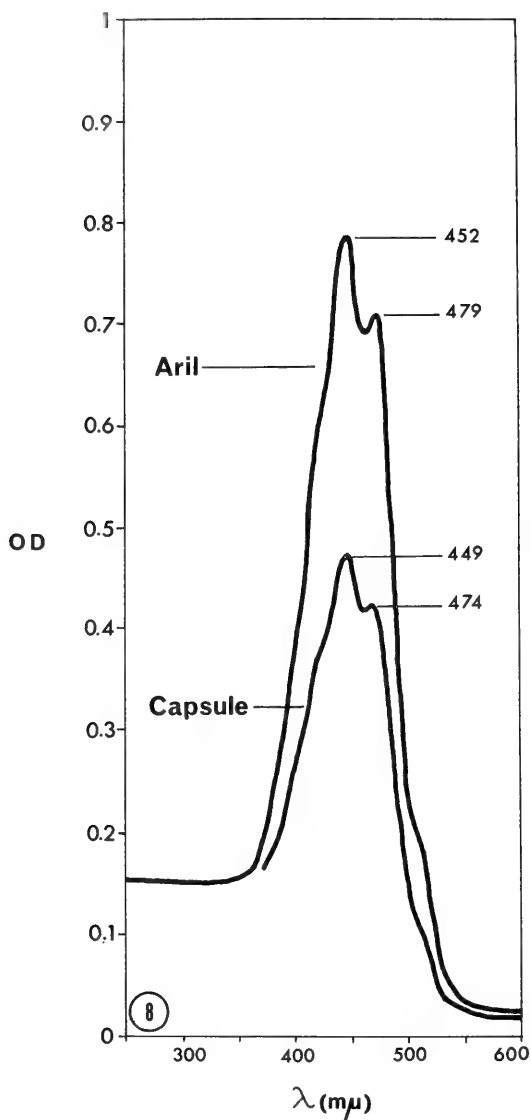


FIG. 8: Absorption spectra of *Celastrus* aril and capsule pigments.

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# STUDIES IN THE XYLARIACEAE: IV.

## *HYPOXYLON*, SECTIONS PAPILLATA AND ANNULATA.†

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### INTRODUCTION

The genus *Hypoxylon* was established in 1791 by Bulliard, and because of its heterogeneity was reconstituted later by Fries in 1849. Unrelated species were excluded and others of close affinity introduced from the original polyglot genus *Sphaeria*. This and subsequent divisions into species groups were almost entirely based on stromal form. Nitschke (1867) and Saccardo (1882 *et seq*) relied primarily on the shape, size and degree of immersion of the stromata in the substrate. As further material was described however, it became evident that these characters could be influenced at least partly by environmental factors as well as by differences in hereditary constitution. Their correct assessment often became an intractable though fascinating problem.

Miller (1928) divided the genus according to the internal characters of the stroma. These included:

- a) the quantity of stroma developed outside the perithecia;
- b) the depth in the wood to which the stromata were sunken;
- c) the colour of the stromal surface and that part immediately below;
- d) the type of ostiole, whether papillate or umbilicate.

His classification, supplemented by the later one of 1961 was as follows:

- Group I. *Euhypoxylon*. Stroma "woody" or corky in texture; ectostroma red or purple, entostroma dark. Ostioles umbilicate.
- II. *Papillata*. Stroma "carbonaceous" or hard and rigid, coloured initially in one subsection; ostioles papillate.
- III. *Annulata*. Stroma carbonaceous; ostioles papillate, each surrounded by an annular disc.
- IV. *Applanata*. Stroma constantly effused, erumpent carbonaceous; ostioles usually papillate.

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In the writer's opinion Miller failed to give sufficient weight to the presence or absence of pigment in his classification. On this criterion Groups I and III and the pigmented species of Papillata would stand closer than the non-pigmented species of Papillata and Group IV. The latter have been placed by the writer respectively in a new section of *Hypoxylon*, Entoleuca, and in the genus *Numulariola*.

Miller describes coloured granules in a few of the pigmented species only, whereas in fact they are a recognizable feature in most of them, although they are not necessarily brilliant in hue and they may not be composed of the same substances. The writer has dissolved fragments of the ectostroma of *Hypoxylon fuscum*, *H. haematostroma*, *H. multiforme*, *H. rubrostromaticum* and *H. thouarsianum* in acetone, and used the filtered solution to make silica gel chromatograms. When examined under UV light none of the chromatograms showed any correlation with respect to the location and colour of fluorescent bands, although there was good correlation between subsequent chromatograms made from different samples of the same species. Neither was there any correlation between the species of *Hypoxylon* and two other species from different genera with coloured ectostroma, *Daldinia concentrica* and *Phylacia turbinata*. On the other hand no coloured pigment could be extracted from species of the section Entoleuca and the genus *Numulariola* exemplified by *H. serpens* and *N. signata*, and none also from *Xylaria poitei*, all of which have a rigid black outer layer of the entostroma and a superficial corky entostroma.

The other features linking the three pigmented groups and dividing them from Entoleuca are the constant position of the germ slit on the convex side of the ascopore and the plate-like shape of the ascal plug, which varies from extremely thin to discoid but is never longer than broad, the universal free-spreading germination pattern, the presence of stain, and absence of carbonaceous deposit in the culture medium. The traditional characters used to separate the groups are not always reliable: the ostioles of some species in the Papillata section may be quite indistinct while papillate ostioles have been seen occasionally in members of Euhypoxylon, and annulate ostioles have been observed sporadically in species of Papillata and in Entoleuca. Nevertheless they are satisfactory in a broad sense and certainly the groups should not be merged until the diverse pigments can be shown to be related in chemical structure.

In the writer's view the Papillata section as redefined (Martin 1967) forms a transition series between Entoleuca and Euhypoxylon. The ectostroma is initially soft and bright coloured, later merging with the entostroma beneath, and becoming hard and dark, but not sloughing off as in many species of Entoleuca (*H. mastoideum*). The entostroma may have a hard, rigid outer layer (*H. multiforme*, *H. cohaerens*) or be corky or brittle throughout as in some strains of *H. investiens*. Both the ectostroma and outer entostroma contain deposits of



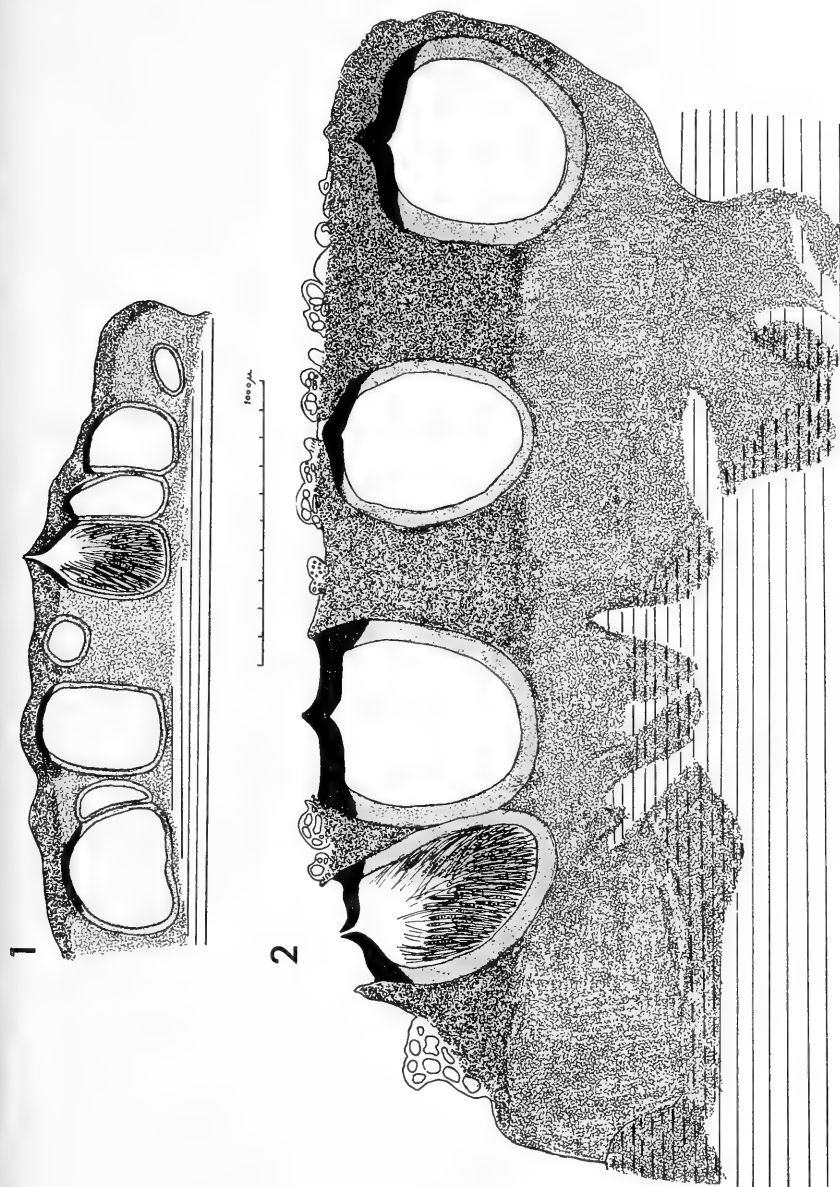


FIG. 1. Vertical sections through Stromata. 1. *Hypoxylon investiens*. 2. *H. denudatum*. Note superficial (coloured) ectostromal granules. Key: Solid black: carbonous perithecial wall. Fine lines: remainder of perithecial wall, dark but less carbonous. Dark mottling: ectostroma and outer entostroma, with pigment and some carbonization. Light mottling: entostroma, basal tissue.

pigment that may appear refractive when the stroma is cut longitudinally. The basal tissue of the entostroma is corky and dark coloured, sometimes massive as in *H. multiforme*.

The Annulata section has basically similar stromata, but the degree of "carbonization" is greater in some species (*H. truncatum*, *H. thouarsianum*) and may extend well beneath the perithecial bases. The ectostroma sloughs away from the ostioles during development leaving circular indentations around them; thus the projecting part of the ostiole consists primarily of the perithecial wall which is dark and rigid. Elsewhere the ectostroma merges with the outer entostroma, sometimes leaving prominent superficial pigmented granules. (Fig. I : 2).

The Euhypoxylon section with some exceptions has softer stromata than in the other two groups, and the differentiation of the stromata varies with the colour and amount of pigment. The ostioles are umbilicate though sometimes raised from the stromal level, or merely indistinct.

Species in culture from these three groups have so far not yielded the *Nodulisporium* stage characteristic of Entoleuca. The Papillata section has the *Sporothrix* type of conidiophore, Annulata *Acrostaphylus*, while Euhypoxylon has both.

#### KEY TO THE SPECIES

- |    |   |   |
|----|---|---|
| 1  | Stroma corky; ectostroma dull or forming a brittle refractive glaze; pigment various, usually recognizable on sight; ostioles umbilicate, sometimes raised above stroma level. . . . . (section Euhypoxylon).   |   |
| 1' | Stroma sometimes corky but characteristically rigid; ectostroma dull or brittle refractive; pigment usually visible only in the developmental stage, but always evident through dissolving stroma in acetone or alcohol; ostioles papillate, sometimes indistinct . . . . . | 2 |
| 2  | Ostioles simple papillate or infrequently annulate papillate, rarely umbilicate; pigment some shade of red or red brown in situ and in solution . . . . . (section Papillata)   | 3 |
| 2' | Ostioles constantly annulate papillate; ectostromal pigment some shade of yellow, green or purple in situ and in solution . . . . . (section Annulata)  | 6 |
| 3  | Stromata small, pulvinate or turbinate, restricted in size though usually closely aggregated; perithecia immersed or vaguely evident. Surface initially purple brown, finally dull black; spores $4.0-6.0 \times 9.0-12.0 \mu$  |   |
|    | <i>Hypoxylon cohaerens</i> Pers. ex Fr.   |   |
| 3' | Stromata applanate or applanopulvinate, crustose, surface differently coloured . . . . .  | 4 |
| 4  | Initial stage of stroma yellow ochre, later brown to black. Perithecia usually sharply distinct in outline, globose, with conspicuous papillate ostioles. Spores $4.0-5.0 \times 8.5-11.0 \mu$  |   |
|    | <i>Hypoxylon multiforme</i> Fr.   |   |

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\*Figures expressed to the first place of decimals represent averages of several measurements to the nearest  $0.5 \mu$ ; integers mere range of dimension.

- 4' Stroma aplanate or aplanopulvinate, crustose, variable in extent, perithecia immersed or with evident varices. Outer layer initially dull brown, orange brown or reddish brown, rarely purple brown, later black; perithecia evident in outline or immersed, with abruptly papillate or indistinct ostioles . . . . . 5
5. Spores  $3.5-6.0 \times 8.0-12.5\mu$  . . . . .  
*Hypoxylon investiens* (Schw.) Curt.
- 5' Spores  $6.0 \times 14.5\mu$  . . . . .  
*Hypoxylon rubigineo-areolatum* Rehm.
- 6 (2) Stromata with ostiolar discs less than  $700\mu$  in diameter . . . . . 8
- 6' Stromata with extremely wide ostiolar discs,  $700-1,000\mu$  in diameter . . . . . 7
7. Spores  $6-7 \times 11-15\mu$ , ave.  $6.5 \times 12.5\mu$  . . . . .  
*Hypoxylon bovei* Speg.
- 7' Spores  $3-4 \times 8-10\mu$  . . . . .  
*Hypoxylon bovei* var. *microspora* Miller.
- 8 (6) Perithecial discs flat to concave . . . . . 10
- 8' Perithecial discs convex; stromata aplanate . . . . . 9
9. Border of discs smooth or decussate; spores  $5.5 \times 11.5\mu$  . . . . .  
*Hypoxylon subannulatum* Henn. & Nym.
- 9' Border of discs abrupt, sharply defined; spores  $4.5 \times 9.5\mu$  . . . . .  
*Hypoxylon archeri* Berk.
10. Stromata predominantly aplanate or aplanopulvinate . . . . . 11
10. Stromata constantly subglobose to hemispheric . . . . . 14
11. Perithecia globose with prominent conical vertices; spores  $4.5 \times 12.5\mu$  . . . . .  
*Hypoxylon michelianum* C. & DN.
- 11' Perithecia oval to globose but with depressed vertices . . . . . 12
12. Spores pale brown subhyaline,  $4.0-6.0 \times 8.0-12.0\mu$ ; stroma conspicuously brick red to metallic purple at maturity . . . . .  
*Hypoxylon denudatum* Petch.
- 12' Spores amber; surface coloration yellow, yellow-green or faintly purple, usually not persistent at maturity . . . . . 13
13. Spores  $2.5 \times 4-9\mu$ , ave.  $2.5-4.0 \times 5.5-8.0\mu$  . . . . .  
*Hypoxylon stygium* (Lev.) Sacc.
- 13' Spores  $3-6 \times 6-12\mu$ , ave.  $3.5-4.5 \times 8.0-10.0\mu$  . . . . .  
*Hypoxylon truncatum* (Schw. ex Fr.) Miller.
- 13'' Spores  $4-5 \times 12-15\mu$  . . . . .  
*Hypoxylon truncatum* var. *pouceanum* (B. & C.) Miller.
- 14 (10) Perithecial discs prominently cupulate; spores  $6-7 \times 9-12\mu$  . . . . .  
*Hypoxylon hians* B. & C.
- 14' Perithecial discs often concave but not prominently cupulate . . . . . 15
15. Spores  $4.5 \times 8.5\mu$  . . . . .  
*Hypoxylon marginatum* (Schw.) Berk.
- 15' Spores  $5.5-6.0 \times 18.0-22.0\mu$  . . . . .  
*Hypoxylon thoursianum* (Lev.) Lloyd.

# ANALYSIS OF SPECIES

## I. Section Papillata.

### A. South African Species.

#### 1. *Hypoxylon investiens* (Schw.) Curtis. Plate I: 1-2, Fig. I: 1.

Berkeley, M. J. Journ. Linn. Soc. **10**, 385, (1869); Grevillea **4**, 52, (1875).  
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*Hypoxylon*, **52**, (1961).

- sub *Hypoxylon anthracoderma* Speg., Penzig O. & P. A. Saccardo, Malpighia II, 491, (1897). Spegazzini C., Anal. Soc. Cient. Arg. **26**, 30 (1888).
- sub *Hypoxylon bakeri* Earle, Earle F. S., Bull. Torrey Bot. Club **26**, 633, (1899).
- sub *Hypoxylon berkeleyi* Sacc., Saccardo P. A., Sylloge Fungorum **9**, 551, (1891).
- sub *Hypoxylon cohaerens* (Pers.) Fr. van *brasiliensis* Starb., Starback K., Bih. K. Svenska Vet. Akad. Handl. **27** (3), 8 (1901).
- sub *Hypoxylon cupricolor* Petch, Petch T., Ann. Roy. Bot. Gard. Perad. **8**, 158, (1924).
- sub *Hypoxylon discoideum* Ellis & Everhart, Ellis J. B. & B. M. Everhart, Proc. Acad. Nat. Sci. Philad III, **23**, 450, (1893).
- sub *Hypoxylon epiphaeum* Berk. & Curt., Berkeley M. J. & M. A. Curtis, Grevillea **4**, 52, (1875).
- sub *Hypoxylon glomeratum* Cke, Cooke, M. C., Grevillea II, 133, (1883). Miller, J. H., Bothalia **4**, 256, 1942.
- sub *Hypoxylon gregale* (Schw.) Curtis, Curtis M. A., Geol. & Nat. Hist. Survey N.C. III, 140 (1867). Ellis, J. B. & B. M. Everhart, North American Pyrenomycetes 657, (1892). Miller J. H., Mycologia **20**, 320, (1928).
- sub *Hypoxylon mascariensis* Berk. ex Cke. Cooke M. C., Grevillea II, 131, (1883).
- sub *Hypoxylon merrilli* Syd. Sydow H. & P., Ann. Mycol. **15**, 212, (1917).
- sub *Hypoxylon plumbeum* Speg. von Hohnel F., Denkschr. Akad. D. Wiss. Wien. Math. nat. Klasse **83**, 26, (1927). Spegazzini C., Anal. Soc. Cient. Arg. **18**, 270, (1884).
- sub *Hypoxylon rubigineo*—*areolatum* Rehm var. *bakeri* (Earle) Mill. Miller, J. H., Journ. Dept. Agric. Puerto Rico **14**, 273, (1930).
- sub *Hypoxylon rubigineo*—*areolatum* Rehm var. *microspora* Theissen. Theissen F., Ann. Mycol. **6**, 345, (1908).
- sub *Hypoxylon subvinosum* Speg. Spegazzini C., Anal. Soc. Cient. Arg. **18**, 269, (1884).
- sub *Sphaeria gregalis* Schw. Fries E. M., Elenchus fungorum II, 68, (1828). Schweinitz, L., Trans. Amer. Phil. Soc. Philad. N S **4**, 193, (1832).
- sub *Sphaeria investiens* Schw. Schweinitz L., Trans. Amer. Phil. Soc. Philad, N S **4**, 193, (1832).

Stromata aplanopulvinate or pulvinate,  $1.1-22 \times 2.0-76 \times 0.5-1.5$  mm., superficial on decorticated wood or bark, usually bright pink or orange brown when young but varying in colour through orange brown, rusty brown, dull brown, purple brown to black at maturity, samples often including a mixture of colours. Acetone extract of stroma deep russet brown. Surface smooth to very uneven or corrugated; ectostroma corky, entostroma hard though not carbonaceous, both dark coloured in longitudinal section. Perithecia varying from completely evident in outline to completely immersed, globose, normally adjacent but not close crowded,  $250-900 \times 300-900\mu$ ; ostioles papillate to

inconspicuous, sometimes encircled by more or less distinct truncate discs. Asci cylindric,  $80-170 \times 4-8\mu$ ; stipes  $22-96\mu$ . Spores gibbous or navicular, ends narrow rounded, medium brown, variable in size,  $3.0-7.5 \times 6.0-18.0\mu$ , ave.  $4.7 \times 10.3\mu$ .

*South African hosts:* *Acacia mollissima* and wood unidentified.

*Material examined:*

sub *Hypoxylon effusum*, Rick; Brazil, (1905), (AA)\*

sub *Hypoxylon epiphaeum*, Kauffmann; on *Magnolia*, Brooksville, Fla; U.S.A. (1918), (AA). Ellis 167; on *Magnolia glauca*, Newfield, N.J., U.S.A., (1894), (AA).

sub *Hypoxylon glomeratum*, Cain; New Durham, Ontario, Canada, (1931), (AA). Ellis 567; Kansas, U.S.A., (1884), (NYBG). Kauffmann; Ann Arbor, Mich., U.S.A., (1922), (AA). Kauffmann; Horseshoe Lake, Ann Arbor, Mich., (1925), (AA). (G.W.) Martin & Weldon 8363; Corundu, Panama Canal Zone, (1952), (NYBG). Seaver 952; St. Croix, West Indies, (1923), (NYBG).

sub *Hypoxylon investiens*, Martin 212; Hogsback, nr. Alice, E. Cape, South Africa, (1958). Martin 381, 1018; Nature's Valley, Knysna District, W. Cape, South Africa, (1958, 1962). Martin 389, 587; Alexandria Forest, E. Cape, South Africa, (1958, 1960). Martin 928, 929; Mazatlán, Sinaloa, Mexico (1961). Martin 953, 959, 967, 971, 972, 975, 976, 979, 983, 995, 1529; San Blás, Nayarit, Mexico, (1961, 1962). Martin 1,079, 1,082, 1,090, 1,091, 1,096, 1,100; Columbia, Mo., U.S.A. (1962). Martin 1,109, 1,122, 1,123, 1,152, 1,157; Lake Ozark, Mo., U.S.A., (1962). Martin 1,628, 1,629; Nyack, N.Y. State, U.S.A., (1963). Martin 1,647; Lake Sebago, Rockland Co., N.Y. State, U.S.A., (1963). Martin 1,765; ex Carroll 118, Vulcan Irazu, Costa Rica, (1962). Shear; Longwood, Fla., U.S.A., (NFC). Ziller 3,562; on *Alnus rubra*, Cooke, B.C., Canada, (FBLBC).

sub *Hypoxylon rubigineo-areolatum*, Rick; Brazil, (1902), (AA).

sub *Hypoxylon rubiginosum*, Kauffmann; Brooksville, Fla. U.S.A., (1919), (AA).

sub *Hypoxylon serpens*, Dingley on *Fuchsia excorticata*; Wairekii, Auckland, New Zealand, (1953), (CMI).

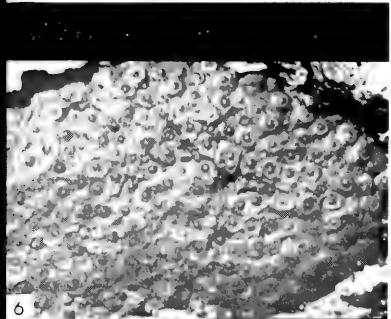
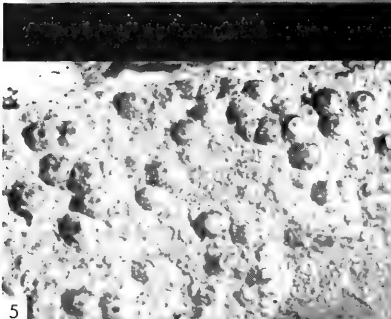
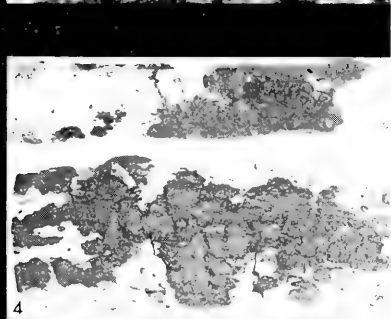
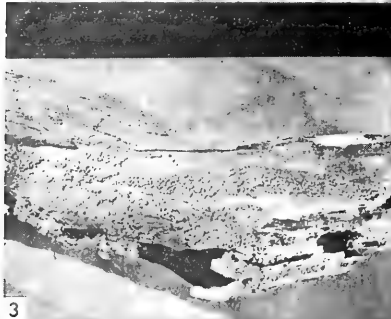
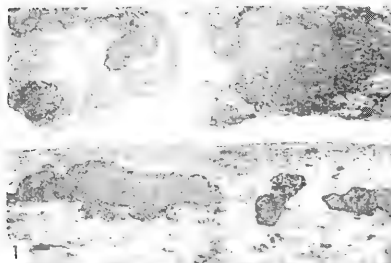
sub *Hypoxylon vinoso-purpureum*, Langlois in Ellis herb. (ined.): La., U.S.A., (NYBG).

*Cultural Characters:* (Plate III: 1—4, Plate IV: 1):

Colonies canescent to velvet-felty, sometimes appressed, usually with a fine texture and rather dense, uniform, dull white. Margin entire, with peripheral hyphae lying together. Stain absent or ochraceous and diffuse, darkening with

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\*See Martin (1968) for list of abbreviations of herbaria.



age to dull brown. Conidial production variable, occurring after 7 days or as much as a month, giving the colony a granular appearance. Growth at 25°C moderate to fast, 3·2—6·5 mm./day.

*Microscopic Characters:* (Fig. III: 1-2):

Primary mycelium not diagnostic; maximum diameter of the marginal hyphae = 2·3 $\mu$ . Secondary mycelium present or absent, if present then ropy or loosely organised, comprising long, frequently septate hyphae 1·5—4·0 $\mu$  diam. occurring at the centre of the colony.

*Conidiophores and conidia* (Fig. III: 3-5):

The occurrence of coremia has not been previously reported for this species but was observed in one strain in culture, where small aggregations of mycelia developed all over the surface of the colony. These measured 0·2—0·3  $\times$  0·4—0·6 mm. and were unbranched, straight, clavate, fertile over the apices and sides, and white in colour. In the other strains the conidiophores were hyphomycetous. In all strains the conidiophores form part of an indefinitely branched system, each conidiophore 75—600 $\mu$  long, dichotomously branched to the second degree or indefinitely, axes 1·5—2·9 $\mu$ ; ultimate fertile branches 11—95  $\times$  1·0—2·5 $\mu$ , smooth with the apices often swollen, entire or sometimes partite forming distinct knobs. The conidia are acrogenous or borne in groups off the sides of the hyphae. The youngest conidium is always in the centre of a fully formed apical cluster. Usually the fertile hypha elongates beyond the site of the first formed conidia so that they later appear to have arisen in fascicles. The conidia are oval or oval-elliptic, sessile and clavate with narrow truncate bases or suspended by sterigmata and pyriform; yellow, pink or dull brown collectively, and extremely variable in size from one strain to another, 1·4—3·4  $\times$  2·0—7·4 $\mu$ , ave. 2·5  $\times$  4·1 $\mu$ .

## 2. *Hypoxylon rubigineo—areolatum* Rehm.

Miller J. H., World species of *Hypoxylon* 52, 1961. Rick J., Broteria Bot. ser. 25, 28, 1931. Theissen F., Ann. Mycol. 7, 146, 1909.

sub *Hypoxylon semi-truncatum* Miller. Miller, J. H., Monogr. Univ. Puerto Rico ser. B 2, 205, 1934.

PLATE I. Stromata. (Magnification: 1, 3 & 4  $\times$  0·4, 2, 5-8  $\times$  3·5).

*Hypoxylon investiens*. 1. General view of stromata. 2. Close-up.

*H. truncatum*. 3. Uni- and multiperitheciate stromata on decorticated wood (*Olea capensis*).

4. Extensive carbonization of bark (*Olea capensis*). 5. Close-up of young stroma with perithecia developing singly; also showing rupture of ectostroma above them.

6. <i>H. truncatum</i>	} mature stromata with annulate ostioles.
7. <i>H. stygium</i>	
8. <i>H. denudatum</i>	

Stromata aplanate, forming thin crusts  $3-13 \times 5-50 \times 0.5-1.0$  mms. high. Surface of ectrostroma brown, sometimes brown with traces of purple, turning black with age; interior dark brown, rather hard, without any apparent differentiation. Acetone extract deep brown. Perithecia evident at least partly in outline or completely immersed, globose, sometimes with conic vertices,  $200-600 \times 500-700\mu$ ; ostioles minutely papillate, indistinct, or occasionally umbilicate or truncate papillate. Asci cylindric or clavate,  $130-170 \times 10\mu$ ; stipes  $45-80\mu$ . Spores oval-elliptic, equilateral, light amber brown,  $45-90 \times 9.0-16.5\mu$ , ave.  $5.6 \times 12.9\mu$ . This species is doubtfully separable from *H. investiens* on account of its spore characters and tropical distribution.

South African hosts: *Olea capensis*, decorticated wood and bark.

*Material examined:*

sub *Hypoxylon atropurpureum*. von Hohnel: on *Fagus*, Jaize, Bosnia, (1901), (AA). Holway sub Ellis 1,180; on *Tilia americana*, Decorah, Iowa, U.S.A. (1882), (AA). Wehmeyer; on *Tilia americana*, Ann. Arbor, Mich. U.S.A. (1924), (AA).

sub *Hypoxylon latissimum*. Costa & Castro 873; Pincorama, Brazil, (1935), (NYBG).

sub *Hypoxylon rubigineo-areolatum*. Martin 379; Nature's Valley, Knysna District, W. Cape, South Africa, (1958). Rick 306; San Leopoldo, Brazil, (1907), (NYBG).

*Cultural Characters:* (Plate III: 5—6):

Colonies dense velvety with fine texture, pure intense white. Margin not distinct, marginal hyphae lying parallel. Conidia develop by 8—14 days, turning the surface granulate pink. Stain absent or faint amber brown. Growth exceedingly slow on malt, 0.1 mm. per day, somewhat faster on maize agar. More cultures are required for study before this can be said to be a specific characteristic.

*Microscopic Characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae  $\approx 2.3\mu$ .

*Conidiophores and conidia* (Fig. III: 6):

Coremia not observed in nature or in vitro. Conidiophores not distinct from the vegetative mycelium, forming branching systems  $130-180\mu$  long, simple or dichotomously or rarely ternately branched to the second degree, axes  $1.6-2.0\mu$ ; fertile branches  $19-130 \times 1.2-1.5\mu$ . Conidia acrogenous or in groups off the sides of the hyphae, borne on slender stigmata, elliptic to pyriform with the basal end tapering to a point, pale pink collectively,  $1.1-2.6 \times 4.6-9.7\mu$ , ave.  $2.0 \times 5.8\mu$ .



**B. Foreign Species.**

3. **Hypoxylon cohaerens** Pers ex Fr. (See Martin (1967) Plate IV: 5).  
Berkeley M. J. in Smith J. E., English flora **5**, (2), 237, (1836); Grevillea **4**, 49, (1875). Bizzozero G., Flora Ven. critt. **1**, 200, (1885). Bresadola G. & P. A. Saccardo., Malpighia **13**, 442, (1889). Chardon C. E., Bol. Real. Soc. Espana Hist. Nat. **28**, 120, (1928). Cooke, M. C., Handbook of British Fungi, **2**, 795, (1871); Handbook of Australian fungi 294, (1892). Currey F., Trans. Linn Soc. Lond. **22**, 266, (1859). Dennis R. W. G., British Cup fungi 177, (1960). De Notaris G., Sferiacei Italici 15, (1863). Ellis J. B. & B. M. Everhart, Journ. Mycol. **4**, 43, (1888); North Amer. Pyren. 635, (1892). Fries E. M., Summa Veg. Scand. 384, (1849). Fuckel L., Symbolae Mycologicae 234, (1869—1870). Junghuhn F. H., Praemissa Fl. Crypt. Javae 19, (1838). Lambotte E., Flore myc. belge 422, (1880). Lloyd C. J., Myc. Writ. 7, 1352, (1925). Miller J. H., Trans Brit. Mycol. Soc. **15**, 138, (1930); World Species of *Hypoxylon* 46, (1961). Nitschke T., Pyr. Germ. **1**, 42, (1867). Quélet, L., Champ. Jura & Vosges **3**, 491, (1875). Rabenhorst G. L., Deutsch. Krypt Flor. **I**, 221, (1844); Krypt Flor. Deutschl. **II**, 858, (1887). Saccardo P. A., Fungi Ital. 570, (1877—1886). Schroter J. in Cohn: Kryptflor Schlesien 460, (1908). Shear C. L., Mycologia **20**, 84, 1928. Starback K., Bih. Svenska. vet. akad. Handl. **27**, (9), 8, (1901). Theissen F., Ann. Mycol. **8**, 453, (1910). Traverso J. B., Flor. Ital. Crypt. **1**, 48, (1906).
- sub *Hypoxylon atrorufum* E. & E. Ellis J. B. & B. M. Everhart, North Amer. Pyren. 742, (1892). Shear C. L., Lloydia **8**, 260, (1945).
- sub *Hypoxylon bagnisii* Sacc. Saccardo P. A., Michelia **1**, 24, (1877). Traverso J. B., Flor. Ital. Crypt. **1**, 48, (1906).
- sub *Hypoxylon turbinatulum* (Schw.) Berk. Berkeley M. J., Grevillea **4**, 51, (1875). Ellis, J. B. & B. M. Everhart, Journ. Mycol. **4**, 43, (1888); N. Amer. Pyren. 636, (1892). Owens C. E., Proc. Indiana Acad. Sci. **1911**, 308, (1912).
- sub *Sphaeria cohaerens* Pers. Albertini J. D. & L. D. de Schweinitz, Consp. Fung. Lusatae 4, (1805). Fries E. M., Systema Myc. 333, (1823); Elenchus Fung. **2**, 63, (1828). Persoon C. H., Syn. Meth. Fung. 11 (1801—1808).
- sub *Sphaeria turbinatula* Schw. Schweinitz L. D., Trans. Amer. Phil. Soc. Philad. N.S. **4**, 192, (1832).

Stromata glomeruliform to pulvinate or aplanopulvinate, usually aggregated and merging into one another, 1.5—4.0 × 1.5—21 × 1.2—3.5 mms., usually erumpent and becoming superficial by attrition of the substrate. Surface somewhat flattened, smooth, initially light brown then dull brown to purple brown or pale purple, becoming purple-black with age. Acetone extract purple brown. Exterior hard, semi-carbonaceous, without apparent differentiation. Perithecia evident at the vertices to completely immersed, oval, longer than broad, 400—

600  $\times$  600—900 $\mu$ ; ostioles medium papillate to minutely papillate or indistinct, occasionally umbilicate. Asci cylindric, 110—135  $\times$  4—5 $\mu$ ; stipes 60—75 $\mu$ . Spores oval-elliptic, gibbous or navicular, medium to chestnut brown, 3.0—7.5  $\times$  6.0—15.0 $\mu$ , ave. 4.5  $\times$  9.4 $\mu$ .

*Material examined:*

*Perfect Stage:* Davidson in FPF 252; on *Fagus grandifolia*, Kirkland, N. B., Canada. Farlow; Newton, Mass., U.S.A., (1893), (AA). Kanouse; on *Betula*, Quincy, Michigan, U.S.A., (1929) (AA). Kauffmann; on *Fagus*, Elkmont, Tenn., U.S.A., (1916), (AA). Kauffmann; on *Acer* sp. Seventh Lake, Adirondack mtns, New York State, U.S.A., (1921), (AA). Martin 624; ex Barnett & Stipes, Morgantown, West Virginia, U.S.A., (1962). Martin 1,600, 1,601, 1,603 (+ *Graphium* imperfect stage); Stoneybrook, Rockland Co., N.Y. State, U.S.A., (1963). Martin 1,719, 1,723; Savoy State forest, Mass., U.S.A., (1963). Martin 1,744; Wine Hill, Oneonta township, Otsego Co., N.Y. State U.S.A., (1963). Martin 1,763; ex Carroll 112, Briar-Patch farm, Austin, Texas, U.S.A., (1960). Martin 1,766; ex Carroll 120, Vulcan Irazu, Costa Rica, (1962). Miller; on *Fagus grandifolia*, Princeton, Ga., U.S.A., (1928), (AA). Schweinitz 1,204; Bethlehem, Pocono, P.; U.S.A., (NYBG).

*Imperfect Stage:*

sub *Isaria virginienensis* E. & E. Nuttall 102; Nuttallburg, W. Va., U.S.A., (1893), (NYBG).

*Cultural Characters:* (Plate III: 7):

Colonies velvet felty, thinly growing with coarse texture, uniform dull white. Margin entire, not distinct, with the peripheral hyphae lying together. Conidia develop by 7 days but are not conspicuous. Stain red-orange to roseate, dispersed. Growth at 25°C moderate, 3—4 mm./day.

*Microscopic Characters:* (Fig. II: 4):

Primary mycelium undiagnostic; maximum diameter of marginal hyphae = 2.3 $\mu$ . Secondary mycelium loosely organized to ropy, 3.1—4.3 $\mu$  diameter.

*Imperfect Stage:* (Fig. II: 3, Plate V: 5—6). See also Martin (1967), Plate IV: 5. Brefeld O. Untersuchungen aus dem Gesamtgebiete der Mykologie X, Ascomyceten 2, 260, (1891). Jaczewski A. L., Bull. Soc. Myc. de France 2, 123, (1895).

The coremial stage mentioned in the literature has been so far only observed in association with developing stromata and not in culture. Fresh material

collected in New York showed that the *Graphium*-type coremia arose from the base of the stromata as in *H. fragiforme* but not forming a distinct circlet, and were decumbent to erect, sometimes rather twisted, measuring  $0.1-0.2 \times 1.7-3.7$  mm., unbranched, dull brown, and fertile over the apices only.

Conidiophores developed on coremia and in culture are identical,  $165-430\mu$  long, dichotomously branched to the first degree over the upper half of the primary axes; axes  $1.5\mu$  diam. The fertile branches are smooth with unspecialized heads,  $21-37 \times 1.2-1.8\mu$ . The conidia are pleuracrogenous or acrogenous, borne on slender sterigmata, oval or clavate with narrow truncate bases, ochraceous,  $1.8-2.5 \times 3.7-4.3\mu$ , ave.  $2.3 \times 4.2\mu$ .

#### 4. *Hypoxylon multifforme* Fries. Plate V: 1 & 3.

Berkeley, M. J. in Smith J. E., *English Flora* 5, (2), 237, (1836); Hooker's *Journ. of Bot.* 6, 226, (1854); Grevillea 4, 49, (1875); *Journ. Linn. Soc.* 14, 351, (1875). Berlèse A. N. & G. Bresadola, *Ann. Soc. Alp. Trid.* 14, 21, (1887—1888). Bizzozero G., *Flora. Ven. critt.* 1, 200, (1885). Cooke M. C., *Handbook of British Fungi* 2, 794, (1871); *Ann. N.Y. Acad. Sci.* 1, 184, (1871); *Handbook of Australian fungi* 294, (1892). Dennis R. W. G., *British Cup Fungi* 177, (1960). Durieu de Maisonneuve M. & J. F. C. Montagne, *Explor. Alger* 1, 452, (1846). Fries E. M., *Summa Veg. Scand.* 384, (1849). Fuckel L., *Symbolae mycologicae* 234, (1869—1870); *Ibid*, *Nachtrag* 1, 37, (1871). Hennings P., *Hedwigia* 42, 82, (1903). Karsten P. A., *Myc. Fenn.* 2, *Pyrenomyces*: 41, (1873). Kickx J., *Flora Crypt. Flandres* 308, (1867). Lambotte E., *Flora Myc. belge* 442, (1880). Lloyd C. G., *Myc. Writ.* 7, 1,312, (1924); *Ibid* 7, 1,364, (1925). Miller J. H., *Journ. Dept. Agric. Puerto Rico* 14, 272, (1930); *Trans. Brit. Mycol. Soc.* 15, 139, (1930); *World Species of Hypoxylon* 48, (1961). Nitschke T., *Pyren. Germ.* 1, 43, (1867). Owens C. E., *Proc. Indiana Acad. Sci.* 1911, 303, (1912). Rabenhorst G. L., *Deutsch. Kryptflor.* I, 221, (1844); *Kryptflor. Deutsch.* III, 857, (1887). Saccardo P. A., *Nuovo Giorn. Bot. Ital.* 8, 184, (1876); *Syll. Fung.* I, 391, (1882); *Fungi Ital.* 573, (1877—1886). Shear C. L., *Mycologia* 20, 85, (1928). Starback K., *Bih. Svenska Vet.-akad. Handl.* 15, 8, (1889); *Ibid* 27, (9), 9, (1901). Sydow H. & F. Petrak, *Ann. Myc.* 20, 184, (1922).

sub *Hypoxylon atropurpureum* (Pers.) Fries. Cook M. C., *Handbook of British Fungi* 2, 796, (1871). Currey F., *Trans. Linn. Soc. Lond.* 22, 267, (1859). Ellis, J. B. & B. M. Everhart, *Journ. Mycol.* 4, 87, (1888); *North Amer. Pyren.* 647, (1892). Fries E. M., *Summa Veg. Scand.* 384, (1849). Jaczewski A. L., *Bull. Soc. Myc. de France* 2, 117, (1895). Nitschke T., *Pyren. Germ.* 1, 48, (1867). Owens C. E., *Proc. Indiana Acad. Sci.* 1911, 300, (1912). Rabenhorst G. L., *Kryptflor. Deutsch.* II, 854, (1887). Saccardo P. A.,

- Nuovo Giorn. Bot. Ital. **8**, 183, (1876); Fungi Ital. 577, (1877—1886).  
 Traverso J. B., Flora Ital. Crypt. **1**, 53, (1906).
- sub *Hypoxylon corrugatum* (Fr.) Cke. Cooke M. C., Grevillea **2**, 129, (1883).
- sub *Hypoxylon crustaceum* (Sow.) Nits. Bresadola G. & P. A. Saccardo, Malpighia **2**, 294, (1897). Ellis, J. B. & B. M. Everhart, Journ. Mycol. **4**, 91, (1888); North Amer. Pyren. 652, (1892). Jaczewski A. L., Bull. Soc. Myc. de France **2**, 118, (1895). Nitschke T., Pyr. Germ. **1**, 49, (1867). Rabenhorst G. L., Kryptflor. Deutsch. **2**, 853, (1887). Spegazzini C., Anal. Soc. Cient. Arg. **18**, 270, (1884). Traverso J. B., Flora Ital. Crypt. **1**, 53, (1906).
- sub *Hypoxylon granulosum* Bull. ex Fr. Bulliard P., Hist. Champ. de Fr. **1**, 176, (1791). Fries E. M., Summa Veg. Scand. 384, (1849). Quélet L., Champ. Jura & Vosges **3**, 491, (1875). Rehm H., Leaff. Philipp. Bot. **8**, 2,958, (1916). Schröter J. in Cohn, Kryptflor Schlesien 460, (1908). Traverso J. B., Flora Ital. Crypt. **1**, 48, (1906).
- sub *Hypoxylon hookeri* Berk. ex Cooke. Cooke M. C., Grevillea **2**, 129, (1883).
- sub *Hypoxylon transversum* (Schw.) Sacc. Saccardo P. A., Syll. Fung. **1**, 391, (1882).
- sub *Peripherostroma granulosum* Gray. Gray S. F., Natural Arrangement of British Plants **1**, 514, (1821).
- sub *Sphaeria atropurpurea* Pers. Fries E. M., Obs. Myc. 174, (1815); Syst. Myc. 340, (1823); Junghuhn F. H., Praemissa Fl. crypt. Javae 18, (1838). Persoon C. H., Syn. Meth. Fung. 18, (1801—1808). Rabenhorst G. L., Deutsch. Kryptflor. I, 219, (1844).
- sub *Sphaeria crustacea* Sow. Sowerby J., English Fungi 1: tab 372, f 11., (1802).
- sub *Sphaeria multiformis* Fr. Fries E. M., Obs. Myc. 169, (1815); Syst. Myc. 334, (1823); Elenchus fung. **2**, 64, (1828). Sommerfelt S. C., Supp. Flora Lapp. 205, (1826).
- sub *Sphaeria peltata* DC. De Candolle A., Flor. Fr. **2**, 287, (1805).
- sub *Sphaeria rubiformis* Pers. Persoon C. H., Syn. Meth. Fung. 9, (1801—1808).
- sub *Stromatosphaeria elliptica* Grev. Greville R. K., Flora edinensis 357, (1824).
- Stromata pulvinate to aplanopulvinate, or aplanate, superficial or erumpent through bark, sometimes linear when protruding through lenticels, as of *Betula*, 2·0—15 × 3·2—84 × 1·1—5·0 mms. Initial stage typically yellow-brown, deepening to dull brown and finally black; purple stromata not seen. Acetone extract of stroma deep brown. Surface of stroma smooth or somewhat granulate, usually convex but flat to concave in lenticular forms; ectostroma corky, entostroma hard externally and corky within. Perithecia completely or partially evident in outline, rarely entirely immersed, globose, 600—1,000 $\mu$ ; stipes 60—117 $\mu$ . Spores oval elliptic, equilateral, gibbous, navicular or crescentic, amber to pale brown, 3·0—6·5 × 7·5—14·5 $\mu$ ; ave. 4·2 × 9·5 $\mu$ .

*Material examined:* A wide range of material in the Ann. Arbor, Helsinki, NFC and NYBG herbaria. Martin 679; culture ex Centraalbureau, Baarn, Holland, (1961). Martin 695, 703, 707; Klamath; Northern California, U.S.A. (1961). Martin 769—771, 784; O'Brien, Northern California, U.S.A., (1961). Martin 793, 797—799, 805, 813, 820, 822, 823, 832—837, 884, 845, 856, 857—860, 862, 876; Arcata, Northern California, U.S.A., (1961). Martin 1,147; Lake Ozark, Mo., U.S.A., (1962). Martin 1,596; Stoneybrook, Rockland Co., N.Y. State, U.S.A., (1963). Martin 1,696; Conway State forest, Mass., U.S.A. (1963). Martin 1,726, 1,731; Savoy State forest, Mass., U.S.A. (1963). Martin 1,807; ex Carroll 119, Vulcan Irazu, Costa Rica, (1963). Martin 1,836; Vancouver, B.C., Canada, (1965).

*Cultural Characters:* (See Martin (1967). Plate II: 2):

Colonies felty, with thin coarse texture, uniform, dull white. Margin not distinct, with peripheral hyphae lying together. Conidia absent or sparsely produced when old. Stain dull buff brown. Growth fast, 6·2—7·5 mm./day at 25°C.

*Microscopic Characters:*

Primary mycelium undiagnostic; marginal hyphae with a maximum diameter of 2·5 $\mu$ . Secondary mycelium loosely organized, 3·0—8·3 $\mu$  diam.

*Imperfect Stage* (Fig. II: 1—2, Plate V: 7):

Brefeld O. Untersuchungen aus dem Gesamtgebiete der Mykologie X, Ascomyceten 2, 260, (1891). Jaczewski A. L., Bull. Soc. Myc. de France 2, 122, (1895).

Coremia unknown in the field or in culture. Conidiophores short, 42—120 $\mu$  long, axes 1·5—1·8 $\mu$  diam., unbranched or branched dichotomously or ternately to the first degree over the upper half of the main axes; some fertile branches in trident formation; fertile branches 12—67  $\times$  1·5—1·8 $\mu$ , smooth, with unspecialized or slightly swollen heads. Conidia acrogenous, on slender sterigmata, elliptic-pyriform, yellow, 1·8—2·5  $\times$  5·6—8·1 $\mu$ , ave. 2·3  $\times$  7·1 $\mu$ .

## II. Section Annulata.

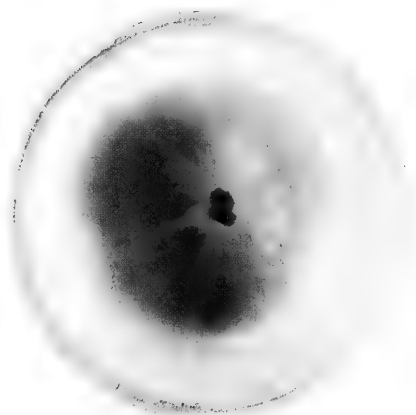
5. *Hypoxylon truncatum* (Schw. ex Fr.) Miller. Plate I: 3—6.

Chardon C. E., Bull. Soc. Venez. Cien. Nat. 40, 31, (1939); *et al.* Mycologia 32, 182, (1940). Miller J. H., Trans. Brit. Mycol. Soc. 17, 130, (1932); Bothalia 4, 254, (1942); Miller J. H., World Species of *Hypoxylon* 95, (1961).

sub *Hypoxylon annulatum* (Schw.) Mont. Chardon C. E., Mycologia 13, 295, (1922). Cooke, M. C., Ann. N.Y. Acad. Sci. 1, 184, (1878); Handbook of



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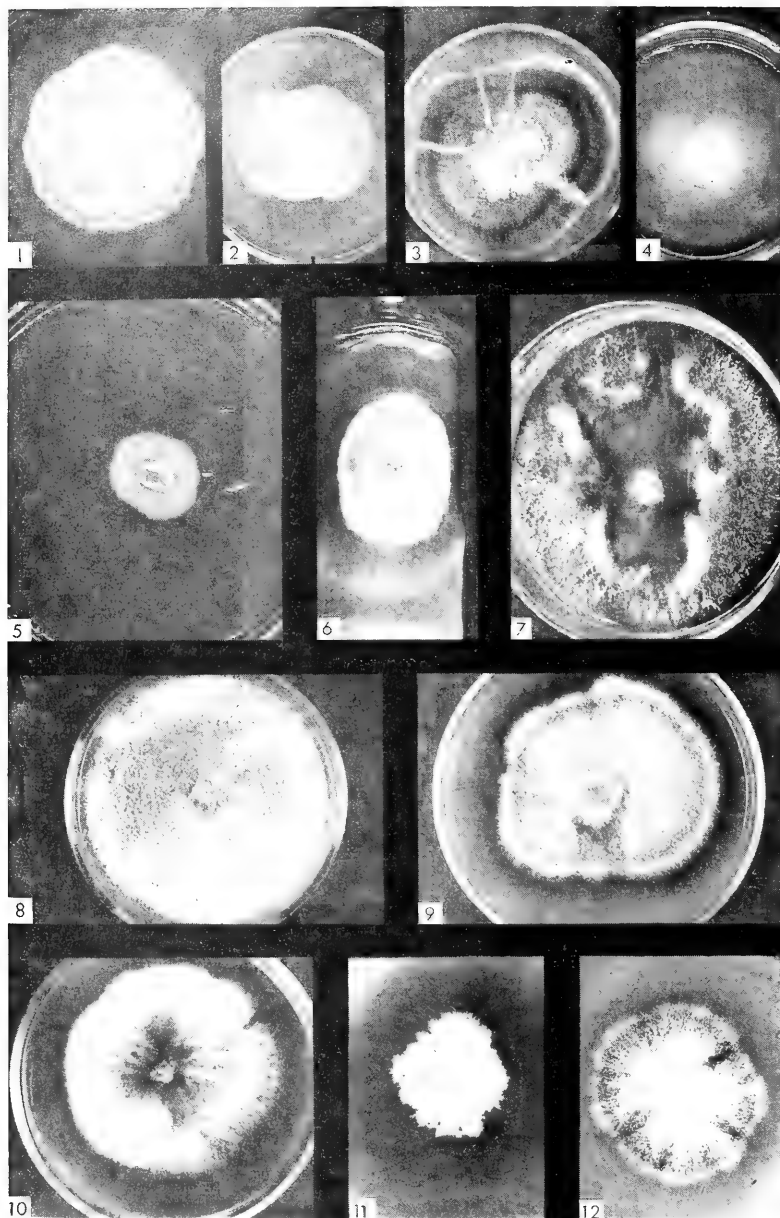
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PLATE II. Colouration.

1. *Hypoxylon truncatum*; bottle cultures 2 weeks old at 25°C. 2. *H. stygium*; reverse of plate culture to show stain.

- Australian Fungi 294, (1892). Currey F., Trans. Linn. Soc. Lond. **22**, 264, (1859). Ellis J. B., Proc. Acad. Nat. Sci. Philad. III, **25**, 27, (1895). Ellis, J. B. & B. M. Everhart, Journ. Mycol. **4**, 68, (1887); North Amer. Pyren. 640, (1892). Hennings P., Hedwigia **47**, 259, (1908). Lloyd C. G., Myc. Writ. **7**, 1,352, (1925). Miller J. H., Mycologia **20**, 317, (1928). Montagne J. F. C. in Gay: Hist. Chile **7**, 445, (1850). Owens C. E., Proc. Indiana Acad. Sci. **1,911**, 307, (1912). Rehm H., Hedwigia **21**, 136, (1882); Leaf. Philipp. Bot. **8**, 2,957, (1916). Rick J., Broteria Bot. Ser. **25**, 22, (1931). Shear C. L., Lloydia **8**, 249, (1945). Starback K., Bih. Svenska ver-akad. Handl. **27**, (9), 7, (1901); Arkiv fur Bot. **5**, 30, 1905. Theissen F., Ann. Mycol. **6**, 536—538, (1908); Ibid **7**, 155, (1909). Viëgas A. P., Bragantia **4**, 101, (1944). Welwitsch F. & F. Currey, Journ. Linn. Soc. **26**, 283, (1868).
- sub *Hypoxylon chalybeum* Berk. & Br. Berkeley M. J. & C. E. Broome, Journ. Linn. Soc. **14**, 121, (1873). Cesati V., Atti. R. Accad. Sci. Fis. e. Matem. **8**, 17, (1879). Petch T., Ann. Roy. bot. gard. Perad. **8**, 151, (1924).
- sub *Hypoxylon apiahynum* Speg. Spegazzini C., Bol. Acad. Nac. Cienc. Cordoba **11**, 506, (1889).
- sub *Hypoxylon circumscribium* Lloyd. Lloyd C. G., Myc. Writ. **7**, 1,312, (1924).
- sub *Hypoxylon glomiforme* Berk. & Curt. Berkeley M. J. Grevillea **4**, 49, (1875). Ellis J. B. & B. M. Everhart, Journ. Mycol. **4**, 43, (1888); North Amer. Pyren. 635, (1892). Shear C. L., Lloydia **8**, 262, (1945).
- sub *Hypoxylon leptascum* Speg. Spegazzini C., Bol. Acad. Nac. Cienc. Cordoba **11**, 507, (1889).
- sub *Hypoxylon moriforme* Henn. Hennings P., Engl. Jahrb. **23**, 287, (1896).
- sub *Hypoxylon murratii* Berk. & Curt. Berkeley, M. J., Grevillea **4**, 49, (1875).
- sub *Hypoxylon piptadeniae* Henn. Hennings P., Hedwigia **48**, 11, (1909).
- sub *Hypoxylon subeffusum* Speg. Rehm H., Leaf. Philipp. Bot. **8**, 2,958, (1916). Spegazzini C., Anal. Soc. Cient. Arg. **18**, 274—275, (1884); Anal. Soc. Cient. Arg. **26**, 32, (1888). Theissen F., Ann. Mycol. **7**, 157, (1909).
- sub *Hypoxylon vernicosum* Ell. & Ev. Ellis J. B. & B. M. Everhart, Amer. Nat. **31**, 426, (1897).
- sub *Sphaeria annulata* Schw. Fries F. M., Elenchus fungorum II, 64, (1828); Schweinitz L., Journ. Acad. Nat. Sci. Philad. **5**, 11, (1825).
- sub *Sphaeria truncata* Schw. Fries E. M., Syst. Myc. II, 442, (1823). Schweinitz L., Syn. Fung. Car. Sup. **44**, (1822).
- sub *Sphaeria truncatula* Schw. Schweinitz L., Syn., Fung. Car. Sup. **210**, (1822).

Stromata variable in appearance, pulvinate to aplanopulvinate, 0.9—31 × 0.9—111 × 0.9—2.0 mms., on bark or decorticated wood. Initial layer yellow to yellow-green, often persistent at maturity as a sterile olivaceous mat encircling the developed stroma; ectostroma crustose, rather thin, with yellow green par-





ticles seen on microscopic examination and yielding an acetone extract of similar colour. Entostroma usually massive, carbonaceous, deep black. Perithecia completely evident to completely immersed, oval or globose,  $800-1,200 \times 800-1,700\mu$ ; ostioles medium papillate surrounded by truncate discs  $0.4-0.7$  mm. diam. Asci cylindric,  $97-170 \times 4-6\mu$ . Spores oval to elliptic, equilateral, gibbous or navicular, amber to medium brown,  $3.0-6.0 \times 6.0-11.5\mu$ ; ave.  $41 \times 8.9\mu$ . The writer considers that *Hypoxylon marginatum*, which has hemispherical stromata, may possibly be a distinct species. Miller regards it as identical with *H. truncatum*.

*South African hosts:* These probably comprise a very wide range and include *Cassine croceum*, *Maytenus buxifolia*, *Olea capensis*, *Royena lucida*, *Trichocladus crinitus*.

*Material examined:* A wide range of material in the Ann. Arbor, CMI, NFC and NYBG herbaria.

Martin 13, 29, 44, 71, 80, 89, 146, 311, 342, 370, 401, 450, 452, 458, 471-473, 475, 477, 486, 1,011, 1,046, 1,047, 1,186; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959, 1962). Martin 224; Hogsback, Alice District, Eastern Cape, South Africa, (1958). Martin 387; Alexandria Forest, Alexandria District, Eastern Cape, South Africa, (1958). Martin 640; Baton Rouge, La., U.S.A., (1961). Martin 939; Mazatlán, Sinaloa, Mexico, (1961). Martin 1,106; Columbia, Mo., U.S.A., (1962). Martin 1,133-1,135, 1,141, 1,180; Lake Ozark, Mo., U.S.A., (1962). Martin 1,520, 1,551; San Blás, Mexico, (1962). Martin 1,770 ex Carroll 130; Vulcan Irazu, Costa Rica, (1962).

*Cultural Characters:* (Plate II: 1, Plate III: 9, Plate IV: 2):

Colonies felty, dense to somewhat sparse, forming an aerial mat of mycelium up to 2 mms. high; surface sometimes smooth but characteristically coarse and often straggling. The colour is white at first, pale yellow by 10 days, then tawny or discoloured, finally dull brown to grey with age. Margin distinct from the rest of the colony, 5-15 mm. broad submersed to canescent, white subhyaline

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PLATE III. Plate Cultures.

All colonies 2 weeks old at 25°C except where stated.

*Hypoxylon investiens*. 1. Malt agar. 2. Leonian's agar, showing fine surface. 3. Colony as in (2), 3 weeks old with coarser surface and brown stain in age. 4. Czapek's agar. *H. rubigineo-areolatum*. 5. Leonian's agar, 4 weeks old. (Malt similar). 6. Maize agar in bottle culture, 4 weeks old. 7. *H. cohaerens*; malt agar. 8. *H. stygium*; malt agar. 9. *H. truncatum*; malt agar. 10. *H. stygium*; Czapek agar. 11-12. *H. denudatum*; Czapek and malt agar respectively.

to colourless, entire with effuse or parallel peripheral hyphae. Conidia are sparsely produced in the centre of the colony, yellow, inconspicuous. Stain deep yellow ochre, tawny, feuille morte or ochre brown at the centre of the colony, lighter outside, and extending beyond the margin in some cultures. Growth on other media broadly similar, but pearly white on maize, and denser on Czapek with roseate or red-ochre stain. Rate of growth moderate to fast, 2·8—5·0 mm./day at 25°C.

*Microscopic Characters* (Fig. III: 7—9):

Primary mycelium without distinguishing character; marginal hyphae with a maximum diameter of 6·0 $\mu$ . Secondary mycelium uniform, rather frequently branched but loosely organized, 2·5—4·6 $\mu$  diam. In one strain dark carbonaceous bodies were observed to develop from small apical or intercalary segments of the hyphae. Segments increased to a maximum diameter of 22 $\mu$  and became black and carbonized as in *H. entoleucum* (Martin, 1968).

*Imperfect Stage.* (Plate V: 8—10, Fig. III: 10):

sub *Hypoxylon annulatum* (Schw.) Mont. Ellis J. B. & B. M. Everhart N. Amer. Pyren. 640, (1892).

sub *Verticillium puniceum* Cke. & Ellis. Cooke M. C. Grevillea 17, 69, (1889).

Conidiophores usually sharply distinct from the vegetative mycelium due to their amber or yellow colouration, pitted walls and determinate growth, 100—690 $\mu$  long, axes 1·8—3·7 $\mu$  in diameter; branched dichotomously, ternately or quadrately to the second degree or indefinitely over the upper halves or in the apical regions of the primary axes. Fertile branches unspecialized, 10—36  $\times$  1·5—3·1 $\mu$ , very occasionally 1—septate, and sometimes rather narrow and attenuated. Conidia borne in apical clusters of 3—8 or sporadically off the sides of the fertile branches, variable in form, usually oval-elliptic or pyriform but occasionally sausage-shaped, equilateral, arising from slender sterigmata, yellow-green collectively, 1·2—2·9  $\times$  3·7—9·7 $\mu$ , ave. 1·8  $\times$  4·8 $\mu$ .

6. *Hypoxylon stygium* (Lév.) Sacc. (Plate I: 7, Plate V: 2 & 4.)

Miller J. H., Trans. Brit. Mycol. Soc. 17, 129, (1932); Monog. Univ. Puerto Rico B 2, 207, (1934); Bothalia 4, 253, (1942); World Species of *Hypoxylon* 91, (1961). Saccardo P. A., Syll. Fung. I, 379, (1882).

sub *Hypoxylon annuliforme* Rehm. Hennings P., Bot., Jahrb. 14, 366, (1892). Rehm H., Verh. Bot. ver Prov. Brandenburg 31, 65, (1890).

sub *Hypoxylon borgoriense* v. Hohn. von Hohnel F., Sitz. k. Akad. d. Wiss. Wien. 118, 341, (1909). Rehm H., Ann. Mycol. 7, 404, (1909).

sub *Hypoxylon microcarpum* Penz. and Sacc. Penzig O. & P. A. Saccardo., Malpighia II, 492, (1897); Icon. Fung. Jav. 26, (1904). Theissen F., Ann. Mycol. 6, 536, (1908).

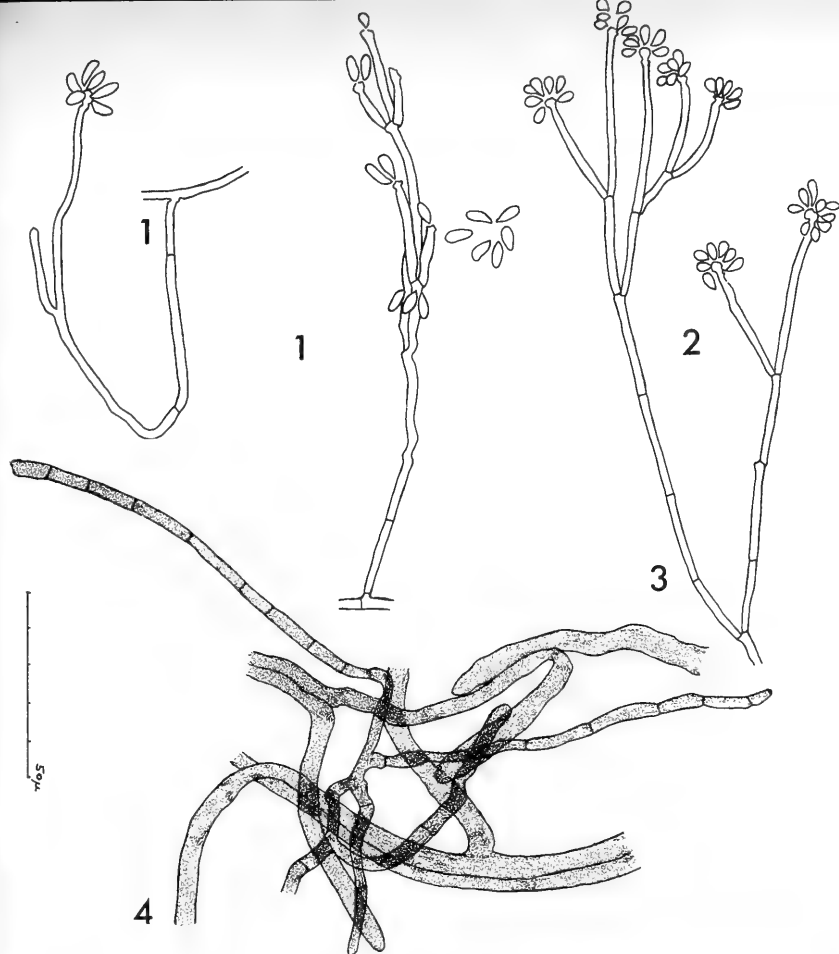


FIG. II. Microscopic characters.

1. *Hypoxylon multifforme*, conidiophores and conidia. *H. cohaerens*. 2. Conidiophore. 3. Conidiophore. 4. Secondary mycelium.

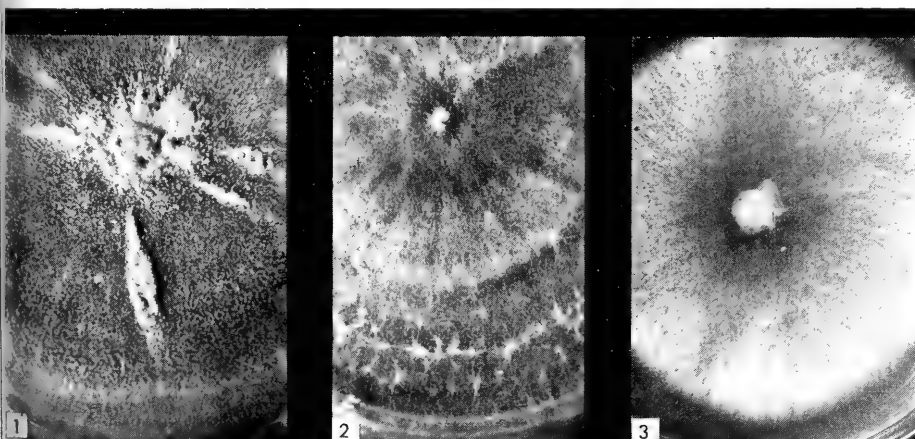


PLATE IV. Close-up of Colony surfaces on malt, 2 weeks at 25°C.

1. *Hypoxylon investiens*. 2. *H. truncatum*. 3. *H. stygium*.

sub *Hypoxylon platystomum* E. & E. Ellis J. B. & B. M. Everhart, N. Amer. Pyren. 649, (1892).

sub *Hypoxylon puiggarii* Speg. Spegazzini C., Bol. Acad. Nac. Cienc. Corboda II, 508, (1889).

sub *Nummularia annulata* Rehm. Rehm H., Ann. Mycol. **11**, 399, (1913).

sub *Nummularia stygia* (Lév.) Lloyd. Lloyd C. G., Myc. Writ. **7**, 1,312, (1924).

sub *Sphaeria platystoma* Fries. Fries E. M., Systema Mycologicum 351, (1823).

sub *Sphaeria stygia* Lév. Léveillé M. J. H., Ann. Sci. Nat. Bot. III, **5**, 258, (1846).

Stromata aplanate crustose, usually on the surface of decorticated wood, 2·8—28 × 12·8—114 × 0·4—2·0 mms. Initial stage dull olive green, sometimes with a red or purplish tint. Acetone extract of stroma olive green. Ectostroma shining black at maturity, rather thin with a smooth surface; entostroma partly carbonaceous but not as massive as in *H. truncatum*. Perithecia evident at vertices to completely immersed, globose or ovate, 500—800 × 750—900 $\mu$ ; ostioles medium papillate surrounded by small truncate discs 0·2—0·3 mms. diameter. Asci cylindric, with stipes of variable length, 54—170 × 3—5 $\mu$ ; stipes 9—105 $\mu$ . Spores oval equilateral, amber, subhyaline, 2·0—5·0 × 4·5—8·5 $\mu$ , ave 2·9 × 6·3 $\mu$ .

South African hosts: *Acacia mollissima*, *Olea capensis*.

#### Material examined:

sub *Hypoxylon bogoriense*, von Hohnel in Rehm 1844; on *Albizia moluccana*, Buitenzorg, Java, (1908), (AA), (NYBG).

sub *Hypoxylon cinnabarinum* Rick; Brazil, (1905), (AA).

sub *Hypoxylon marginatum* Rick; Brazil, (1907), (AA).

sub *Hypoxylon platystomum* Kauffmann; Brooksville, Fla., U.S.A., (1918), (AA). Kauffmann; Brooksville, Fla., U.S.A., (1919), (AA). Langlois 2,333; on *Melia*, St. Martinsville, La., U.S.A., (1890), (NYBG).

sub *Hypoxylon polyspermum* Calkins in Ellis & Everhart's N. Amer. Fungi 1788; Florida, U.S.A., (1886), (AA). Kauffmann; on *Carpinus*, Little River, Fla., U.S.A., (1919), (AA).

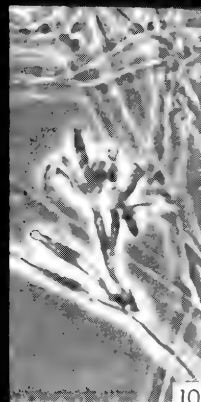
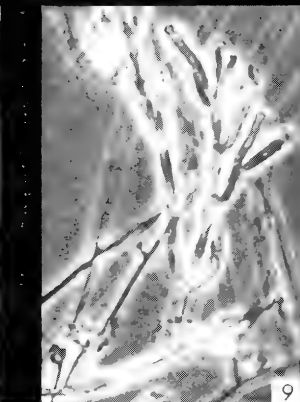
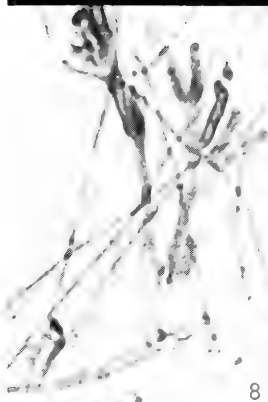
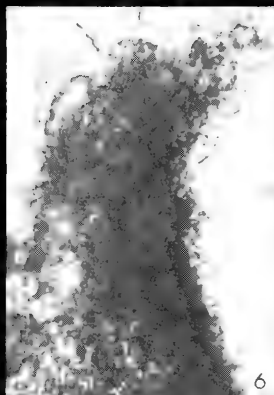
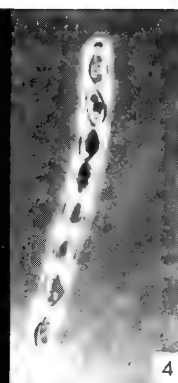
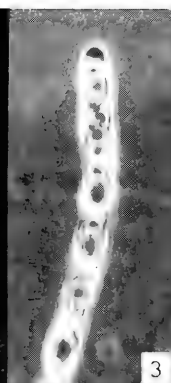
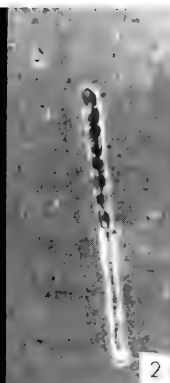
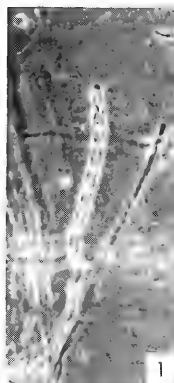
sub *Hypoxylon sanguinosum* Rick; Brazil, (1932), (AA).

sub *Hypoxylon stygium* Martin 234; Hogsback, nr. Alice, Eastern Cape, South Africa, (1958). Martin 968, 1,509, 1,519, 1,521, 1,548, 1,552; San Blàs,

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#### PLATE V.

1—4. Asci and spores. 1 & 2. *Hypoxylon multifforme* and *H. stygium*. X 290. 3 & 4. Same, showing detail of spores and ascial plugs. X 720. 5—6. *H. cohaerens*, coremia developed in culture. 5. X 110. 6. X 290. 7. *H. multifforme*, smooth conidiophore. X 720. 8—10. *H. truncatum*, warted conidiophores. 8. Bright field. X 720. Note colouration in main axes. 9. The same, phase contrast. 10. Smaller conidiophore, branching pronouncedly verticillate.



Nayarit, Mexico, (1961, 1962). Martin 1,017; Nature's Valley, Knysna District, Western Cape, South Africa, (1962). Martin 1,075, 1,076; Hawaii, (1962). Martin 1,768, 1,769; ex Carroll 125, 127, Puerto Vieho, Costa Rica, (1963). Parks 22,371; Rarotonga, Maungatoa mtn., Hawaii, (AA), (1929). Theissen in Rehm's *Ascomyceten* 2,086; Sao Paulo, Brazil, (AA.)  
sub *Nummularia rufa* E. & E. Smith 54; Nicaragua, (1893), (NYBG).

*Cultural Characters:* (Plate II: 2, Plate III: 8 & 10, Plate IV: 3):

Colonies felty, with a moderately coarse to smooth surface, and aerial mycelium up to 2 mms. high; dull white usually tinted cream or greenish by 2 weeks and becoming grey with age. In one bottle culture the colours were restricted to zones of the aerial mycelium so that there was alternation between shades of yellow and yellow-grey. Margin usually distinct depending on the degree of development of the aerial mycelium; up to 5 mm. broad, canescent to submersed, colourless, entire, with peripheral hyphae widely dispersed. Conidia pale yellow-green to fawn, formed sparsely or in small pulvinate groups over most of the colony, appearing by 7—10 days or with age. Stain amber to chestnut brown, sometimes olive green, diffuse in bottle culture but in plates characteristically appearing as a broad ring just behind the margin of the colony and then spreading inwards to the centre. Growth on other media besides malt is broadly similar but colours tend to be more intense and guttation of stain as blood red drops may occur on maize agar and on Czapek agar. Growth rate on malt agar fast, 5.0—6.5 mm./day.

*Microscopic Characters:*

Primary mycelium undiagnostic; marginal hyphae broad, up to  $3.7\mu$  diam. Secondary mycelium loosely anastomosed, frequently branched, hyphae  $1.5$ — $6.0\mu$  diam.

*Conidiophores and conidia* (Fig. III: 12):

The conidiophores are clearly distinct from the vegetative mycelium by the slightly greater width of hyphae, fine wall pitting and deep amber to yellow colour. They are  $90$ — $250\mu$  long with axes  $1.8$ — $4.0\mu$  diameter, and are branched to the first or second degree dichotomously, ternately or quadrately over the upper halves or terminal portions of the main axes only. Fertile branches usually

FIG. III. Microscopic Characters.

- 1-5. *Hypoxyton investiens*. 1. Marginal hypha. 2. Secondary mycelium. 3. Whole conidiophores, to small scale (strain 212). 4. Apices of conidiophores, enlarged (strain 212). 5. Smaller conidiophores of strain 389; same scale as in (4). 6. *H. rubigineo-areolatum*; conidiophores and spores. 7-10. *H. truncatum*. 7. Marginal hypha. 8. Secondary mycelium. 9. Development of carbonous bodies, cf. *H. entoleucum* (Martin, 1968). 10. Conidiophore. 11. *H. denudatum* conidiophore. 12. *H. stygium* conidiophore.



in trident formation, smooth, sometimes with globose apices,  $9-30 \times 1.4-3.0\mu$ . Conidia acrogenous, in clusters of 6-12; oval, equilateral or pyriform, borne on slender sterigmata, yellow or yellow-green collectively, turning to fawn,  $2.0-2.6 \times 3.1-5.6\mu$ ; ave.  $2.2 \times 4.2\mu$ .

7. *Hypoxylon denudatum* Petch. Plate I: 8, Fig. I: 2.

Petch T. Ann. roy. bot. gard. Perad. 8, 154, 1924.

Stromata aplanate or pulvinate, normally multiperitheciate but also comprising forms where the perithecia are single or loosely aggregated;  $0.6-5.7 \times 0.6-8.0 \times 1.2-1.7$  mms. The colour of the young and early mature stroma varies from brick red to metallic purple. Acetone extract russet-purple. Ectostroma slight; entostroma usually fairly well developed, externally carbonaceous. Perithecia evident to base or only vaguely in outline, globose to oval variable in size,  $550-1,000 \times 550-1,300\mu$ ; ostioles medium papillate, encircled by truncate discs  $0.3-0.5$  mm. diam. Asci cylindric,  $120-180 \times 4-5\mu$ ; stipes  $50-90\mu$ . Spores oval-elliptic, light brown, subhyaline,  $3.0-7.0 \times 7.0-12.5\mu$ ; ave.  $4.5 \times 9.4\mu$ .

*South African Hosts: Olea capensis.*

*Material examined:* Martin 511, 556; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959). Martin 563; Mt. Misery, nr. Grahamstown, E. Cape, South Africa, (1960).

*Cultural Characters* (Plate III: 11-12):

Colonies at first appressed felty, later characteristically becoming denser with coarse cottony surface. Aerial mycelium up to 3 mm. high, white subhyaline near the margin but variable in colour toward the centre, normally cream to primrose yellow at first, later tinted dull green and after a month murky grey. Margin usually distinct, up to 12 mms. broad entire, effuse. Conidia produced early in some cultures, late in others, granulate to smooth, dense, pale purplish brown to mousegrey. Stain variable usually produced in less than a week, extending to but not beyond the margin where it shows up behind the mycelium; roseate brown or warm sepia deepening to chestnut and finally dull black, rarely however olive green. Cultures on other media similar, those on Czapek more brilliant in hue and guttating drops of dark brown stain.

*Microscopic Characters:*

Primary mycelium undiagnostic, marginal hyphae with a maximum diameter of  $2.9\mu$ . Secondary mycelium loosely organized, closely branched,  $1.9-3.6\mu$  diam.



*Conidiophores and conidia* (Fig. III: II):

Conidiophores distinct from the vegetative mycelium in wider diameter, wall pitting, and vinaceous red tint. They are long,  $270\text{--}350\mu$ , branched dichotomously or ternately to the first degree over the terminal portion or upper halves of the main axes which are  $2.1\text{--}2.3\mu$  in diameter. Fertile branches  $13\text{--}40 \times 1.5\text{--}1.9\mu$ , lying free or in trident position. Conidia acrogenous or occasionally produced either singly or in groups of 2 to 3 from the sides of the fertile branches, usually close to a septum. Conidia variable in form, usually oval-elliptic to pyriform but occasionally elongated and sausage shaped, equilateral or inequilateral, borne on slender sterigmata,  $1.2\text{--}2.3 \times 3.7\text{--}9.7\mu$ ; ave.  $1.9 \times 5.3\mu$ .

The taxonomic position of this species and others in the annulate group with reddish stromata, such as *H. microcarpum* Penz. & Sacc. and *H. platystomum* E. & E., seems to be unresolved. Miller considers that they are all synonymous with *H. stygium*; the writer finds that while many samples of *H. stygium* have a red or purplish tint, a combination of deep purple colour in the stroma, red or purplish conidiophores and reddish brown stain in culture, further minor differences in cultural characters and a higher average ascospore size and darker colour of the ascospores should serve to classify other samples in a separate species. To date Petch's specific name seems to be the most appropriate.

8. *Hypoxylon thouarsianum* (Lév.) Lloyd.

Lloyd C. G., Myc. Writ. 6, 102, (1919). Miller J. H., World Species of *Hypoxylon*, 87, (1961), (including var. *gilletianum*, Ibid p. 89).

sub *Hypoxylon amaniensis* P. Hennings. Hennings P., Bot. Jahrb. 38, 115, (1907).

sub *Hypoxylon gilletianum* Sacc. Saccardo P. A., Ann. Mycol. 4, 76, (1906).

sub *Hypoxylon malleolus* Berkeley. Berkeley M. J., Grevillea 4, 49, (1875).

Cooke, M. C., Ann. N.V. Acad. Sci. 1, 184, (1878). Ellis, J. B. & B. M. Everhart, Journ. Mycol. 4, 43, (1888); N. Amer. Pyren. 635, (1892). Lloyd C. G., Myc. Writ. 6, 901, (1919).

sub *Hypoxylon occidentale* E. & E. Ellis J. B. & B. M. Everhart, Proc. Acad. Nat. Sci. Philad. III, 24, 345, (1894).

sub *Sphaeria thouarsiana* Lév. Léveillé M. J. H., Ann. Sci. Nat. Bot. III, 5, 258, (1846).

Stromata pulvinate to hemispheric,  $4.0\text{--}40 \times 4.0\text{--}51 \times 2.2\text{--}22$  mms., superficial on wood. Ectostroma slight; entostroma massive in development, carbonaceous to corky at the base, often showing traces of zonation in longitudinal section. Acetone extract olive green. Perithecia evident at vertices or immersed, oval,  $600\text{--}900 \times 800\text{--}1,100\mu$ ; ostioles medium papillate, discs  $0.3\text{--}0.5$  mm. diam. Asci not seen. Spores crescentic with acute or narrowly rounded ends, pale brown,  $4.5\text{--}7.5 \times 15.0\text{--}28.0\mu$ ; ave  $5.8 \times 20.0\mu$ .

South African hosts: *Olea capensis*.

*Material examined*: Martin 30, 37, 40, 53, 90, 115, 125, 314, 346, 459, 1,013, 1,049, 1,190; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959, 1962). Martin 265, 266; Alexandria Forest, Eastern Cape, South Africa, (1958). Martin 615; Malibu Canyon, Los Angeles, California, U.S.A. (1961). Martin 689, 690; Stanford Botanical Reserve, Palo Alto, California, U.S.A., (1961). Martin 775; O'Brien, Northern California, U.S.A. (1961).

This species has not been cultured successfully despite repeated attempts. Olive green mycelium and disintegrated conidiophores similar to those of *H. truncatum* have been observed on parts of the stromata.

#### ACKNOWLEDGEMENTS

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# NOTES ON A CYCAD COMMUNITY AND ASSOCIATED VEGETATION IN NATAL

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## INTRODUCTION

The following account and preliminary check-list of a cycad (*Encephalartos natalensis*) community and the associated vegetation is based on observations made and plants collected on a number of visits to the site during 1966. The cycads are on a farm Hopewell (1: 250,000 Topocadastral Map, 1953), in the Richmond district of Natal, owned by Mr. A. E. Mapstone. The cycad site is about 14 km south of Thornville Junction at the intersection of co-ordinates 29° 50' south and 30° 25' east (Fig. 1).

An interesting feature of the community is the presence of many pre-angiosperm plants. According to records, including Dyer (1965), the cycads are at least 50 million years old and evolved during the Carboniferous or Permian periods. The large number of ferns (*Polypodium polypodioides*, *Pleopeltis macrocarpa*, *Asplenium* spp. and *Vittaria isoetifolia*), lycopods (*Lycopodium gnidioides* and *L. verticillatum*), various mosses and lichens adds to the conclusion that this is an ancient plant community, the relic of a past age, and is worthy of permanent record.

Under present environmental conditions there is no danger of this cycad population dying out, as there is evidence of vigorous regeneration in the immediate vicinity of the adults. Small seedlings, 0.5 m high with a single leaf, were common in rock crevices, sheltered from direct sunlight, where leaf-mould had accumulated. Seedling mortality rate, however, must be great as the proportion of seedlings to young adults is high.

## GEOMORPHOLOGY AND SOILS

A prominent topographic feature of the area is a 50 m high, northwest-facing faultline scarp with downthrow to the northwest. The resistant band of Table Mountain Sandstone along the edge of the scarp has been incised at right angles by a small tributary of the Mlazi River.

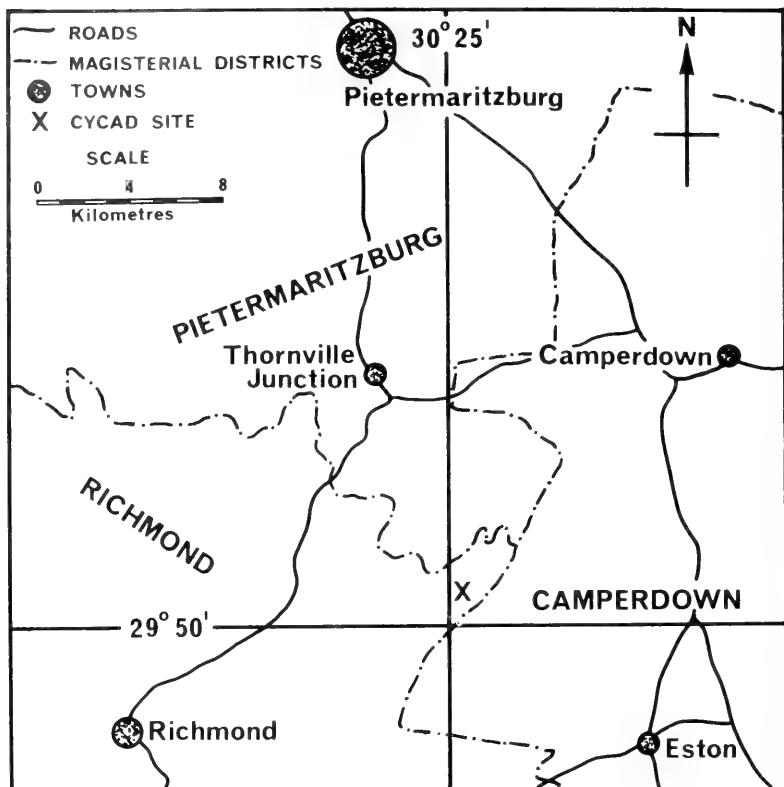


FIGURE 1.  
The location of the Cycad site.

Soils on the level ground above the scarp are sandy and shallow, especially towards the edge of the scarp. Sandstone talus boulders litter the steep slopes where the soil is likewise sandy and shallow.

#### CLIMATE

Summarized climatic data (Fig. 2) for Pietermaritzburg (Weather Bureau, 1954), the nearest weather station, give some indication of the climate prevailing at Hopewell.

Differential insolation between aspects has a major discriminative influence on vegetation in Natal: soils of north-facing slopes become warmer and drier than those of south-facing slopes. This phenomenon is illustrated at Hopewell where, on the north-facing slopes a dry woodland vegetation is found, while on the more mesic south-facing slopes scrub-forest is developed.

Frost is considered a more important limiting factor for the distribution of many plants in Natal than high temperatures. From observation, plants are better able to recover from severe wilting, caused by high air temperature and associated low humidity, than from the effect of sub-zero temperatures. The cultivation in the district of sugar cane, a tropical crop, suggests that Hopewell is relatively frost free.

#### VEGETATION

##### *Cycad community*

Three large clumps and numerous scattered individuals of *E. natalensis* were found on a boulder littered slope where the scarp has been incised by the

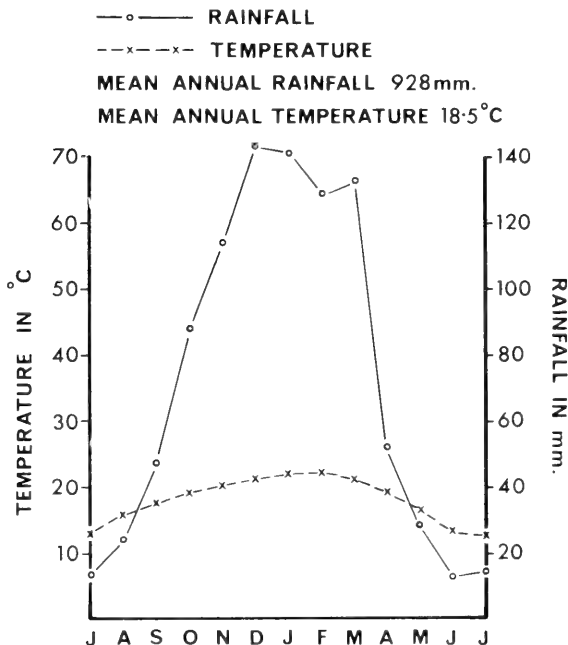


FIGURE 2.  
 Summarized climate data for Pietermaritzburg (after Walter, 1963).

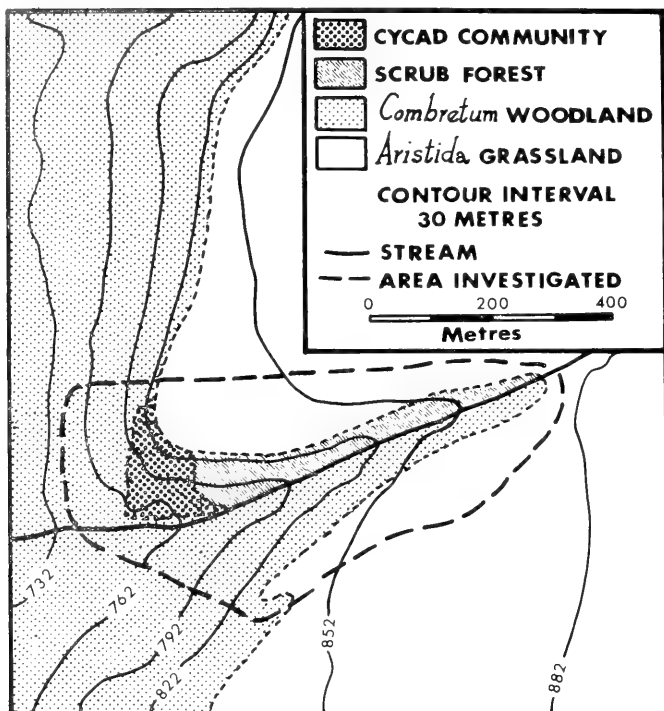


FIGURE 3.  
Topographic map of the Cycad site showing the approximate boundaries of the communities discussed and the area investigated in detail.

stream (Fig. 3). The terrain is exceedingly rugged, consisting of large blocks of sandstone talus. Little soil is found, except where it has accumulated between boulders and is held by a fibrous root-mat.

Individual cycad trees may be 4–5 m high with stems 30–50 cm in diameter, each stem being terminated by a rosette of leaves in typical cycad fashion. Over sixty crowns were counted in the population and 50% had cones, in the ratio of one male to every two females.

Investigation of the large clumps showed that each comprised some 20 stems, derived from probably six to ten “parent” individuals which have produced suckers from the base to form an aggregate individual of up to 12 stems (Plate 1). Dyer (1965) suggests that although individual stems may be as much

as 500 years old, the rootstocks which produce suckers may be a thousand or more years old.

Epiphytes are common on the cycads, especially towards the apices where there is more shading by the apical rosette of leaves. The persistent leaf bases and alternating woolly bracts provide an ideal substrate (Plate 2). The most common epiphytes are lichens, bryophytes, ferns (*Polypodium polypodioides* and *Asplenium* spp.) and angiosperms (*Angraecum conchiferum*, *Mystacidium gracile*, *Peperomia reflexa* and *Crassula* spp.).

Associated trees in the Cyad Community are *Urera tenax*, *Calpurnia aurea* and *Clausena anisata* and these attain a height of 3—5 m. More occasional trees are *Ficus burtt-davyi* and *Clerodendrum glabrum*. Shrubs such as *Grewia occidentalis* and *Iboza riparia* also occur.

#### Scrub-forest

Scrub-forest is found on the south-facing, boulder strewn slopes of the small valley. It extends from the upper reaches of the stream to the cycad community.

Three ill-defined layers may be distinguished in the scrub-forest though



PLATE 1.  
A clump of eight specimens of *E. natalensis* growing from a single rootstock.



PLATE 2.

Epiphytic *Crassula* sp., *Polypodium polypodioides* and *Asplenium* sp. on *E. natalensis*.

a certain amount of disturbance, such as the cutting of poles and the movement of cattle through the forest, prevents the development of true stratification. The upper canopy varies considerably in height from 4—13 m, and in most parts a closed canopy is formed. Composition is rather mixed, the more common canopy species being *Rapanea melanophloeos*, *Canthium mundianum*, *Xymalos monospora*, *Clerodendrum glabrum* and *Kiggelaria africana*.

From the composition of the canopy species, and with some knowledge of their performance in Natal, it is evident that the climatic climax in this area is not tall forest typical of comparable areas such as Table Mountain (Killick,



1959). The species are almost wholly pioneer or forest margin trees capable of tolerating a wider range of climatic conditions than climax forest species. For this reason, and because of the poor development of strata, the forest is referred to as scrub-forest.

Below the canopy is a discontinuous and ill-defined shrub layer. Common species present are *Maytenus mossambicensis*, *Tricalysia lanceolata*, *Clausena anisata*, *Canthium ciliatum* and *Dracaena hookeriana*.

The field layer is very poorly developed owing to the rugged terrain. Some of the common species are *Cyperus albostratus*, *Panicum aequinerve*, *Diets vegeta* and *Impatiens duthieae*.

A feature of this and other scrub-forest in Natal is the abundance of lianes. The most common species are *Cnestis natalensis* and *Acacia ataxacantha*. These are of ecological significance as they greatly increase the density of the canopy.

#### *Combretum* Woodland

Open or closed *Combretum* Woodland with a short herbaceous understory, occurs on the steep, dry, north-facing scarp slopes (Plate 3). The trees present are fairly uniform in height, 3—4 m, and most are deciduous or semi-deciduous



PLATE 3.

*Combretum* Woodland, showing *Combretum gueinzii* and *Aloe candelabrum* with *Aristida junciformis* grassland understory. Note the scattered talus boulders.

during the dry winter season. Common species are *Combretum gueinzii*, *Aloe candelabrum*, *Dombeya rotundifolia*, *Acacia* spp., *Erythrina latissima* and *Sclerocarya caffra*.

Shrubs are present though very scattered, the most frequent being *Lantana rugosa* and *Lippia javanica*.

Common plants of the herbaceous layer are grasses such as *Hyparrhenia hirta*, *Themeda triandra*, *Aristida junciformis*, *Heteropogon contortus*, *Eragrostis capensis*, *Tristachya hispida* and *Rhynchelytrum setifolium*. These species form a layer up to 1 m high and common associated herbs are *Thesium costatum*, *Cyanotis nodiflora*, *Acalypha glabrata* and numerous other species, especially legumes and composites.

Rock outcrops are common in the *Combretum* Woodland and have a distinct flora, with *Ficus* spp., *Ekebergia pterophylla* and *Canthium mundianum* the most common trees.

The grass management policy of the area is to burn-off the grassland in autumn or winter, the fires being started on the flat area above the scarp slope. One factor limiting *Combretum* Woodland to the steep slopes is the absence of hot grass fires from such areas. On level ground, where the soil is deeper and the grass cover better, fires are usually hot enough to kill, or seriously retard most of the woody vegetation. On steep slopes with shallow soils, fires, although occurring, are not as fierce. The fires, usually fanned by a slight wind, burn fiercely to the edge of the scarp slope then burn slowly down the slope where there is little wind fanning the blaze.

#### *Aristida* Grassland

Grassland of mixed composition, with *Aristida junciformis* as the main constituent, is found on the flat land above the scarp slope. The soils are generally greater than 30 cm deep, except towards the edge of the scarp where they became very shallow and the sandstone itself is exposed.

Near the cliff edge, stages in the succession from lithosere to grassland are found as the soil gets progressively deeper. Pioneer invaders of bare rocks are lichens followed by *Selaginella mitenii* which forms extensive mats over the rocks (Plate 4). Soil particles are held by the fibrous root system and these mats are invaded by pioneer angiosperms such as *Aristida barbicollis*, *Loudetia simplex*, *Bulbostylis* spp., *Mariscus* spp. and *Commelina* spp.

The fire climax grassland, known as Open Bush Sandy (Pentz, 1943) or Ngongoni Veld (Acocks, 1953), has a variety of species present. Common grasses are *Aristida junciformis*, *Hyparrhenia* spp., *Heteropogon contortus*, *Themeda triandra*, *Alloteropsis semialata* and *Brachiaria serrata*. Associated grassland species are not common, which is a feature of this type of grassland.



PLATE 4.

Grassland covering shallow soil above the scarp, the common grass is *Aristida junci formis*. The fault-formed valley is in the middle-distance.

#### ACKNOWLEDGEMENTS

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figures, the Head of the Botany Department of the University of Natal, Pietermaritzburg for facilities and the Chief and staff of the Botanical Research Institute for naming some of the specimens.

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## LIST OF PLANTS RECORDED

(Nomenclature after (i) ALSTON, A. H. G. AND SCHELPE, E. A. C. L. E. (1952). An annotated check-list of the Pteridophyta of Southern Africa. *J. S. Afr. Bot.*, **18**; and (ii) PHILLIPS, E. P. (1951). *The Genera of South African flowering plants*. Govt. Printer: Pretoria.)  
 The collection of vascular flora given in this list is not comprehensive, but includes the majority of species occurring in the area.

Species within genera have been arranged alphabetically.

Abbreviations following each species show the distribution within the area and are taken from Fig. 3; here A=*Aristida* Grassland, C=Cycad Community, F=Scrub-forest and W=*Combretum* Woodland.

## PTERIDOPHYTA

## Lycopodioides

## LYCOPODIACEAE

- Lycopodium gnidioides* L. . . . . (C)  
*L. verticillatum* L.f. . . . . (C)

## SELAGINELLACEAE

- Selaginella dregei* (Presl) Hiern . . . . . (C, F)  
*S. mittenii* Bak. . . . . (A)

## Filicales

## POLYPODIACEAE

- Oleandra distenta* Kunze . . . . . (C)  
*Pteridium aquilinum* (L.) Kuhn . . . . . (A, C, F, W)  
*Chvilanthus multifida* Sw. . . . . (C)  
*Pellaea calomelanos* (Sw.) Link . . . . . (A, C)  
*P. viridis* (Forsk.) Prantl var. *glauca* Sim . . . . . (A, C)  
*Vittaria isoetifolia* Bory . . . . . (C)  
*Asplenium aethiopicum* (Burm.) Bech. . . . . (C)  
*A. rutaefolium* (Berg.) Kuntze . . . . . (C)  
*A. theciferum* (H.B.K.) Mett. var. *concinna* (Schrad.) C. Chr. . . . . (C)  
*Fleopeltis macrocarpa* (Bory ex Willd.) Kaulf. . . . . (C)  
*Polypodium polypodioides* (L.) Hitchc. s. sp. *ecklonii* (Kunze) Schelpe . . . . . (C)

## SPERMATOPHYTA

## Gymnospermae

## CYCADACEAE

- Encephalartos natalensis* Dyer and Verdoorn . . . . . (C)

## Angiospermae

## JUNCAGINACEAE

- Triglochin bulbosa* L. . . . . (A)

## GRAMINEAE

- Imperata cylindrica* (L.) Beauv. var. *africana* (Anders.) C. E. Hubb. . . . . (W)  
*Trachypogon spicatus* (L. f.) Kuntze . . . . . (A, W)  
*Bothriochloa insculpta* (Hochst.) A. Camus . . . . . (W)  
*Cymbopogon excavatus* (Hochst.) Stapf . . . . . (C, F, W)  
*C. plurinodis* Stapf . . . . . (A, C, F, W)  
*Hyparrhenia filipendula* (Hochst.) Stapf . . . . . (A, C, W)  
*H. hirta* (L.) Stapf . . . . . (A, W)  
*Monocymbium ceresiforme* (Nees) Stapf . . . . . (A)  
*Heteropogon contortus* (L.) Beauv. . . . . (A, W)  
*Themeda triandra* Forsk. . . . . (A, W)  
*Perotis patens* Gand. . . . . (W)  
*Paspalum commersonii* Lam. . . . . (A, W)  
*P. dilatatum* Poir. . . . . (A, W)  
*P. notatum* Flüge . . . . . (A, W)  
*Alloteropsis semialata* Hitch. var. *ecklonii* Stapf . . . . . (A)  
*Brachiaria serrata* (Spräng.) Stapf . . . . . (A, W)  
*Panicum aequiervae* Nees . . . . . (C, F)  
*P. maximum* Jacq. . . . . (C, F)  
*Digitaria longiflora* (Retz.) Pers. . . . . (C, F, W)  
*D. natalensis* Stent . . . . . (C, F, W)  
*Rhynchelytrum repens* (Willd.) C. E. Hubb. . . . . (A, W)  
*R. setifolium* (Stapf) Chiov. . . . . (A, W)  
*Optismenus hirtellus* (L.) Beauv. . . . . (F)  
*Setaria chevalieri* Stapf . . . . . (F)

- S. flabellata* Stapf . . . . . (W)  
*S. sphacelata* (Schumach.) Stapf and C. E. Hubb. . . . . (W)  
*Ehrharta erecta* Lam. . . . . (C, F)  
*Aristida barbicollis* Trin and Rupr. . . . . (A)  
*A. junciformis* Trin. and Rupr. . . . . (A, W)  
*Sporobolus capensis* (Willd.) Kunth . . . . . (A, W)  
*S. fimbriatus* Nees . . . . . (A, W)  
*S. pyramidalis* Beauv. . . . . (A, W)  
*S. stapfianus* Gand. . . . . (A, W)  
*Tristachya hispida* (Thunb.) K. Schum. . . . . (A, W)  
*Loudetia simplex* (Nees) C. E. Hubb. . . . . (A, W)  
*Microchloa caffra* Nees . . . . . (A)  
*Harpechloa falx* (L.) Kuntze . . . . . (A, W)  
*Chloris gayana* Kunth . . . . . (A, W)  
*Eleusine indica* Gaertn. . . . . (W)  
*Pogonarthria squarrosa* (Licht.) Pilger . . . . . (W)  
*Trichoneura grandiglumis* (Nees) Stapf and C. E. Hubb. . . . . (W)  
*Eragrostis capensis* (Thunb.) Trin. . . . . (A, W)  
*E. curvula* (Schrud.) Nees . . . . . (A, W)  
*E. plana* Nees . . . . . (A, W)  
*E. racemosa* (Thunb.) Steud. . . . . (A, W)
- CYPERACEAE**  
*Pycreus flavescens* Reichb. . . . . (A)  
*P. polystachyus* Beauv. . . . . (A)  
*Cyperus albostratus* Schrad. . . . . (C, F)  
*C. semitrifidus* Schrad. . . . . (A)  
*C. sphaerospermus* Schrad. . . . . (A)  
*C. tenax* Boeck. . . . . (A)  
*Mariscus capensis* Schrad. . . . . (A, W)  
*M. marlothii* C.B.Cl. . . . . (A)  
*M. sieberianus* Nees . . . . . (A, W)  
*M. vestitus* C.B.Cl. . . . . (A)  
*Kyllinga erecta* Schumach. . . . . (A)  
*Fimbristylis dichotoma* (L.) Vahl . . . . . (A)  
*F. monostachya* (L.) Hassk. . . . . (A, W)  
*Bulbostylis collina* (Kunth) C.B.Cl. . . . . (A, W)  
*B. humilis* Kunth . . . . . (A, W)  
*B. oritrepes* (Ridl.) C.B.Cl. . . . . (A)  
*Schoenoxiphium caricoides* C.B.Cl. . . . . (F)
- ARACEAE**  
*Stylochiton natalense* Schott . . . . . (A)  
*Zantedeschia aethiopica* Spreng. . . . . (W)
- COMMELINACEAE**  
*Commelina africana* L. . . . . (A, W)  
*C. benghalensis* L. . . . . (A, W)  
*Cyanotis nodiflora* Kunth . . . . . (W)
- LILIACEAE**  
*Chlorophytum comosum* (Thunb.) Jacques (F)  
*Eriospermum luteo-rubrum* Bak. . . . . (F)  
*Aloe arborescens* Mill. . . . . (W)  
*A. candelabrum* Berger . . . . . (W)  
*A. saponaria* (Ait.) Harv. . . . . (A, W)  
*Tulbaghia acutiloba* Harv. . . . . (A)  
*Drimis alta* R. A. Dyer. . . . . (A)  
*Dracaena hookeriana* K. Koch. . . . . (F)  
*Sansevieria guineensis* (L.) Willd. . . . . (F, W)  
*S. thyrsiflora* Thunb. . . . . (F, W)  
*Asparagus racemosus* Willd. . . . . (F)  
*Behnia reticulata* Didrichs . . . . . (F)
- AMARYLLIDACEAE**  
*Haemanthus natalensis* Pappe . . . . . (C, F)  
*Hypoxis filifolia* Bak. . . . . (A, W)  
*H. rigidula* Bak. . . . . (A, W)
- DIOSCOREACEAE**  
*Dioscorea cotinifolia* Kunth . . . . . (C, F)  
*D. sylvatica* Eckl. . . . . (C, F)
- IRIDACEAE**  
*Dietes vegeta* (L.) N.E.Br. . . . . (F)  
*Lapeirousia laxa* (Thunb.) N.E.Br. . . . . (W)  
*Watsonia densiflora* Bak. . . . . (A)
- ORCHIDACEAE**  
*Stenoglottis fimbriata* Lindl. . . . . (C)  
*Angraecum conchiferum* Lindl. . . . . (C)  
*Mystacidium gracile* Harv. . . . . (C, F)
- PIPERACEAE**  
*Peperomia reflexa* (L. f.) A. Dietr. . . . . (C, F)
- ULMACEAE**  
*Trema orientalis* (L.) Blume . . . . . (F, W)
- MORACEAE**  
*Ficus burtt-davyi* Hutch. . . . . (C, W)  
*F. capensis* Thunb. . . . . (F)  
*F. ingens* Miq. . . . . (W)  
*F. natalensis* Hochst. . . . . (F)  
*F. sonderi* Miq. . . . . (W)
- URTICACEAE**  
*Urena tenax* N.E.Br. . . . . (C)  
*Fleurya mitis* Wedd. . . . . (F)
- SANTALACEAE**  
*Thesium costatum* A. W. Hill . . . . . (A, W)
- POLYGONACEAE**  
*Rumex sagittatus* Thunb. . . . . (W)  
*Polygonum salicifolium* Brouss. . . . . (W)
- AMARANTHACEAE**  
*Cyathula cylindrica* Moq. . . . . (A, W)  
*Achyranthes aspera* L. . . . . (W)  
*Gomphrena decumbens* Jacq. . . . . (W)
- RANUNCULACEAE**  
*Clematis brachiata* Thunb. . . . . (F)
- MENISPERMACEAE**  
*Cissampelos mucronata* A. Rich. . . . . (C, F, W)
- CARYOPHYLLACEAE**  
*Dianthus basuticus* Burtt Davy var. *grandiflorus* Hooper. . . . . (W)  
*Drymaria cordata* Willd. . . . . (W)
- ANNONACEAE**  
*Popowia caffra* (Sond.) Benth. . . . . (F)
- MONIMIACEAE**  
*Xymalos monospora* Baill. . . . . (F)
- CRASSULACEAE**  
*Crassula heterotricha* Schinz . . . . . (C)  
*C. lineolata* Dryand. . . . . (C)  
*C. setulosa* Harv. . . . . (C)
- PITTSPOREACEAE**  
*Pittosporum viridiflorum* Sims . . . . . (F)
- ROSACEAE**  
*Rubus rosaeifolius* L. . . . . (F)

## CONNARACEAE

*Cnestis natalensis* Planch. and Sond. . . . (F)

## LEGUMINOSAE

*Acacia ataxacantha* DC. . . . . (F, W)  
*A. caffra* (Thunb.) Willd. . . . . (W)  
*A. gerrardii* Benth. . . . . (W)  
*A. nilotica* (L.) Del. . . . . (W)  
*Dichrostachys cinerea* (L.) Wight and Arn. . . . . (W)  
*Cassia plumosa* (E. Mey.) Vogel . . . . . (W)  
*Entada spicata* (E. Mey.) Druce . . . . . (F)  
*Crotalaria capensis* Jacq. . . . . (A, W)  
*Trifolium burchellianum* Ser. . . . . (W)  
*Calpurnia aurea* (Ait.) Benth. . . . . (C, F)  
*Dichilus lebeckioides* DC. . . . . (W)  
*Indigofera tristitoides* N.E. Br. . . . . (W)  
*Tephrosia polystachya* E. Mey. . . . . (W)  
*Zornia capensis* Pers. . . . . (A, W)  
*Dalbergia obovata* E. Mey. . . . . (F, W)  
*Abrus precatorius* L. . . . . (W)  
*Erythrina humeana* E. Mey. . . . . (W)  
*E. latissima* E. Mey. . . . . (W)  
*E. lysistemon* Hutch. . . . . (W)  
*Rhynchosia caribaea* DC. . . . . (A, W)  
*Vigna vexillata* Benth. . . . . (A, W)  
*Dolichos falcatus* Klein ex Willd. . . . . (F)

## GERANIACEAE

*Pelargonium aconitophyllum* Eckl. and Zeyh. . . . . (F)  
*P. alchemilloides* (L.) Ait. . . . . (F)

## ERYTHROXYLACEAE

*Erythroxylum emarginatum* Thonn. . . . (F)

## RUTACEAE

*Fagara capensis* Thunb. . . . . (F, W)  
*Vepris undulata* Verdoorn . . . . . (F)  
*Clausena anisata* (Willd.) Hook. f. . . . (C, F)

## BURSERACEAE

*Commiphora harveyi* Engl. . . . . (F)

## MELIACEAE

*Ekebergia pterophylla* (C. DC.) O. Hoffm. (W)

## POLYGALACEAE

*Polygala hottentotta* Presl. . . . . (A)  
*P. serpentina* Eckl. and Zeyh. . . . . (A)  
*P. virgata* Thunb. . . . . (F)

## EUPHORBACEAE

*Micrococca capensis* (Baill.) Prain. . . . (F)  
*Acalypha glabrata* Thunb. . . . . (W)  
*Jatropha hirsuta* Hochst. . . . . (A)  
*Clusia pulchella* L. . . . . (F, W)  
*Excoecaria simii* (Kuntze) Pax. . . . . (W)  
*Euphorbia clavarioides* Boiss. . . . . (W)  
*E. ingens* E. Mey. . . . . (W)

## ANACARDIACEAE

*Sclerocarya caffra* Sond. . . . . (W)  
*Rhus dentata* Thunb. . . . . (F, W)  
*R. fraseri* Schönl. . . . . (W)  
*R. macowanii* Schönl. . . . . (W)  
*R. pentheri* Zahlbr. . . . . (W)

## AQUIFOLIACEAE

*Ilex mitis* (L.) Radlk. . . . . (F)

## CELASTRACEAE

*Maytenus heterophylla* (Eckl. and Zeyh.) H. K. B. Robson. . . . . (F, W)  
*M. mossambicensis* (Klotzsch) Blakelock (F)  
*M. nemorosus* (Eckl. and Zeyh.) Marais (W)  
*M. peduncularis* (Sond.) Loes. . . . . (F)  
*M. undata* (Thunb.) Blakelock. . . . . (F)  
*Pterocelastrus echinatus* N.E. Br. . . . . (F)  
*Cassine tetragona* Loes. . . . . (W)

## SAPINDACEAE

*Allophylus dregeanus* (Sond.) De Winter (F)  
*A. erosus* Radlk. . . . . (F, W)  
*A. melanocarpus* (Sond.) Radlk. . . . . (F)  
*Hippobromus pauciflorus* Radlk. . . . . (F, W)

## MELIANTHACEAE

*Bersama stayneri* Phill. . . . . (F)

## BALSAMINACEAE

*Impatiens duthieae* L. Bol. . . . . (F)

## RHAMNACEAE

*Ziziphus mucronata* Willd. . . . . (W)  
*Phytica paniculata* Willd. . . . . (F, W)  
*Helinus integrifolius* (Lam.) Kuntze . . . (W)

## VITACEAE

*Rhoicissus rhomboidea* (E. Mey. ex Harv.) Planch. . . . . (C, F)  
*R. tomentosa* (Lam.) Wild and Drummond (C, F)

## TILIACEAE

*Grewia occidentalis* L. . . . . (C, F, W)  
*Triumfetta pilosa* Roth. var. *tomentosa* Szyszyl. ex Sprague and Hutch. . . . . (F)

## MALVACEAE

*Pavonia columella* Cav. . . . . (W)

## STERCULIACEAE

*Dombeya cymosa* Harv. . . . . (W)  
*D. rotundifolia* Planch. . . . . (W)  
*D. tiliacea* (Encl.) Planch. . . . . (F)

## OCHNACEAE

*Ochna arborea* Burch. ex DC. . . . . (F)  
*O. atropurpurea* DC. . . . . (W)

## FLACOURTIACEAE

*Kiggelaria africana* L. . . . . (F)

## OLINIACEAE

*Olinia emarginata* Burt Davy . . . . . (F)

## THYMELAEACEAE

*Lasiophon kraussii* Meisn. . . . . (F)

## COMBRETACEAE

*Combretum erythrophyllum* (Burch.) Sond. (W)  
*C. gueinzii* Sond. . . . . (W)

## MYRTACEAE

*Eugenia albanensis* Sond. . . . . (F)

## ARALIACEAE

*Cussonia spicata* Thunb. . . . . (W)

## UMBELLIFERAE

- Heteromorpha trifoliata* (Wendl. and Bartl.)  
Eckl. and Zeyh. . . . . (F)

## MYRSINACEAE

- Maesa lanceolata* Forsk. . . . . (F, W)  
*Myrsine africana* L. . . . . (A, F, W)  
*Rapanea melanophloeos* (L) Mez. . . . . (F)

## EBENACEAE

- Euclea natalensis* A. DC. . . . . (F)  
*Diospyros lycioides* Desf. . . . . (A, F, W)

## SALVADORACEAE

- Azima tetraacantha* Lam. . . . . (W)

## LOGANIACEAE

- Buddleia dysophylla* (Benth.) Radlk. . . . . (C, F)

## GESNERIACEAE

- Sebaea grandis* (E. Mey.) Steud. . . . . (W)

## APOCYNACEAE

- Carissa bispinosa* (L.) Desf. ex Brenan . . . . . (F)

## ASCLEPIADACEAE

- Riocrexia torulosa* Decne. . . . . (A)  
*Tenaris simulans* N.E.Br. . . . . (A)  
*Asclepias multicaulis* Schltr. . . . . (A)  
*Ceropegia meyeri* Decne. . . . . (A)

## BORAGINACEAE

- Ehretia rigida* (Thunb.) Druce. . . . . (W)

## CONVOLVULACEAE

- Evolvulus alsinoides* L. . . . . (A, W)

## VERBENACEAE

- Lantana rugosa* Thunb. . . . . (W)  
*Lippia javanica* (Burm. f.) Spreng. . . . . (W)  
*Clerodendrum glabrum* E. Mey. . . . . (C, F, W)

## LABIATAE

- Leonotis leonurus* R.Br. . . . . (F)  
*Stachys cooperi* Skan . . . . . (F)  
*Plectranthus ciliatus* E. Mey. ex Benth. . . . . (F)  
*P. fruticosus* L'Hér. . . . . (F)  
*P. tomentosus* Benth. . . . . (F, W)  
*Iboza riparia* N.E.Br. . . . . (C, F, W)  
*Syncolostemon lanceolatus* Guerke . . . . . (W)  
*Becium obovatum* N.E.Br. . . . . (A, W)

## SOLANACEAE

- Lycium acutifolium* Miers . . . . . (W)  
*Solanum giganteum* Jacq. . . . . (W)  
*S. gracile* Dun. . . . . (W)  
*S. mauritanium* Scop. . . . . (F, W)

## SCROPHULARIACEAE

- Diclis reptans* Benth. . . . . (A)  
*Halleria lucida* L. . . . . (F)  
*Bowkeria triphylla* Harv. . . . . (F)  
*Sutera floribunda* Kuntze . . . . . (W)  
*Ilysanthes nana* Engl. . . . . (A)  
*Hebenstreitia elongata* Bol. . . . . (A)  
*Selago natalensis* Rolfe. . . . . (A)  
*Striga asiatica* (L.) Kuntze. . . . . (A)  
*S. bilabiata* (Thunb.) Kuntze . . . . . (A)

## GESNERIACEAE

- Streptocarpus haygarthii* N.E.Br. ex C.B.Cl.  
(F)

## ACANTHACEAE

- Justicia protracta* (Nees) T. Anders. . . . . (W)  
*Chaetacanthus setiger* (Pers.) Lindl. . . . . (W)  
*Ruellia cordata* Thunb. . . . . (W)  
*Barleria meyeriana* Nees . . . . . (W)  
*Rhinacanthus communis* Nees . . . . . (W)

## RUBIACEAE

- Burchellia bubalina* (L. f.) Sims . . . . . (F)  
*Xeromphis rudis* (E. Mey. ex Harv.) Codd . . . . . (W)  
*Gardenia neuberia* Eckl. and Zeyh. . . . . (F)  
*Rothmannia globosa* (Hochst.) Keay . . . . . (F)  
*Tricalysia lanceolata* Sond. . . . . (F, W)  
*Pentanisia prunelloides* (Klotzsch) Walp. . . . . (A, W)

- Vangueria infausta* Burch. . . . . (W)  
*Canthium ciliatum* (Klotzsch) Kuntze. . . . . (F)  
*C. inerme* (L. f.) Kuntze . . . . . (F, W)  
*C. mundianum* Cham. and Schlectd. . . . . (F, W)  
*Pachystigma latifolium* Sond. . . . . (W)  
*P. macrocalyx* (Sond.) Robyns. . . . . (W)  
*Galopina circaeoides* Thunb. . . . . (W)  
*Dioclia natalensis* (Hochst.) Garcia . . . . . (W)  
*Pavetta breyeri* Brem. . . . . (F)  
*P. lanceolata* Eckl. . . . . (F)

## DIPSACACEAE

- Scabiosa columbaria* L. . . . . (A, W)

## CUCURBITACEAE

- Coccinia rehmannii* Cogn. . . . . (W)

## CAMPANULACEAE

- Wahlenbergia madagascariensis* A. DC. . . . . (W)  
*W. undulata* (Thunb.) A. DC. . . . . (W)  
*W. zeyheri* Eckl. and Zeyh. . . . . (W)  
*Lobelia decipiens* Sond. . . . . (A)  
*Cucumis zeyheri* Sond. . . . . (A)

## COMPOSITAE

- Vernonia corymbosa* Less. . . . . (F)  
*Erigeron floribundus* (H.B.K.) Sch. Bip. . . . . (W)  
*Brachylaena elliptica* Less. . . . . (W)  
*Helichrysum appendiculatum* (L. f.) Less. . . . . (W)  
*H. aureo-nitens* Sch. Bip. . . . . (A, W)  
*H. decorum* DC. . . . . (A)  
*H. ericaefolium* Less. . . . . (A)  
*Bidens pilosa* L. . . . . (W)  
*Cineraria atriplicifolia* DC. . . . . (W)  
*Senecio bupleuroides* DC. . . . . (A)  
*S. inaequidens* DC. . . . . (A)  
*S. latifolius* DC. . . . . (A)  
*S. oxyriaefolius* DC. . . . . (A, W)  
*S. polyanthemoides* Sch. Bip. . . . . (W)  
*S. striatifolius* DC. . . . . (A, W)  
*Berkheya bipinnatifida* (Harv.) Roessler s. sp.  
bipinnatifida . . . . . (F)  
*Dicoma anomala* Sond. . . . . (W)  
*Gerbera kraussii* Sch. Bip. . . . . (A, W)  
*Crepis hypochaeridea* (DC.) Thell. subsp.  
genuina (Thell.) Babc. . . . . (W)





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'n ANATOMIESE EN ONTOGENETIESE  
STUDIE VAN DIE WORTELS VAN  
SUID-AFRIKAANSE LILIACEAE:

VI. SEKONDÊRE DIKTEGROEI BY *ALOE ARBORESCENS* MILL. EN  
'N TABEL WAARIN DIE SOORTE MET MEKAAR VERGELYK WORD  
TEN OPSIGTE VAN BELANGRIKE ANATOMIESE KENMERKE.\*†

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ABSTRACT

The roots of *Aloe arborescens* show a considerable increase in diameter after the completion of primary growth. This increase in diameter is largely the result of overall cell division followed by cell enlargement in the parenchymatous ground tissue, particularly that of the central cylinder. Except for the periderm, no cambial layer nor a radial arrangement of secondary cells could be observed in any part of the root.

Secondary vascular tissues (usually grouped together in bundles) differentiate scattered within the stele. These bundles are imbedded in a sclerenchymatous tissue.

This type of secondary activity may be termed "diffuse secondary growth".

INLEIDING

Die ontwikkeling van periderm by *Aloe arborescens* is bespreek in 'n vorige publikasie (Pienaar, 1968, C). In die huidige ondersoek word dus slegs verwys na die moontlike sekondêre weefselontwikkeling wat plaasvind in die res van die wortel.

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\* Deel van 'n verkorte weergawe van 'n proefskrif goedgekeur vir die graad van Doktor in die Natuurwetenskappe aan die Universiteit van Stellenbosch, September 1965.

† Aanvaar vir publikasie 3 Oktober 1968.

In die huidige ondersoek is vasgestel dat sommige van die wortels van *Aloe arborescens*, aan die einde van primêre ontwikkeling, 'n deursnee van sowat 0.5 cm bereik. Ouer dele van dieselfde wortels bereik egter 'n deursnee van sowat 1 tot 2 cm naby die wortelbasis. Hieruit is afgelei dat, behalwe vir 'n peridermlaag, die wortels na voltooiing van primêre ontwikkeling moontlik toeneem in dikte deur sekondêre weefselontwikkeling.

Lindinger (1906) vind dat die meristeem wat verantwoordelik is vir die diktegroei in wortels van *Dracaena*-soorte, sy oorsprong het in die skors. 'n Soortgelyke meristeem kon hy nie vasstel in die wortels van „baie ou eksemplare” van *Aloe arborescens*, *A. plicatilis* en *A. succotrina* nie.

Lindinger (1909) het vasgestel dat die wortels van *Aloe dichotoma* nie toeneem in dikte as gevolg van die aktiwiteit van 'n spesiale sekondêre meristeem nie, maar wel deur 'n vermeerdering in die aantal skorslae, gevolg deur 'n toename in grootte van die individuele selle. Hy skryf verder dat dit waarskynlik die geval is by al die Aloineae.

In verband met sekondêre diktegroei by die wortels van die Liliaceae, is reeds baie navorsing gedoen met *Dracaena*-soorte (vgl. Scott en Brebner, 1893; De Silva, 1936; Cheadle, 1937; Joshi, 1939). Uit die resultate van hierdie navorsers blyk dit dat sekondêre ontwikkeling eerstens toegeskryf word aan die aktiwiteit van die perisikel wat 'n kambium vorm. Dit word gevolg deur 'n kambiumlaag wat ontstaan in die binneskors. Cheadle wys daarop dat die sekondêre weefsels radiaal gerangskik is as gevolg van die periklinale verdelings in bogenoemde twee meristematiese streke.

#### MATERIAAL EN METODES

Sien Pienaar (1968 a, p. 38–39 en 1968 b, p. 92–93).

#### ONDERSOEK

*Die anatomie van die wortel van Aloe arborescens aan die einde van primêre ontwikkeling (jong wortel) en daarna (ou wortel).*

Die jong wortels het 'n deursnee van sowat 0.5 cm terwyl ouer wortels 'n deursnee van sowat 1—2 cm bereik naby die wortel-basis.

#### Epidermis

En laag epidermisselle is aanwesig by die jong wortel. Hierdie selle besit 'n protoplasmatiese inhoud en die buitewande is effens verdik en verkurk (vgl. Pienaar, 1968 c, fig. 5). In die ou wortel vergaan die epidermis en die eksodermis en 'n aantal kurklae vorm die beskermende mantel van die wortel.

#### Skors

In die jong wortel differensieer die buitenste laag skorsselle as 'n eksodermis wat bestaan uit twee soorte selle, nl. sommige wat dunwandig en sonder proto-

plasmatiese inhoud is en ander met 'n protoplasmatiese inhoud en waarvan die buitenste tangensiale wande sterk verdik en effens verkurk is. Laasgenoemde is die deurlaatselle. In die ou wortel het die eksodermis vergaan.

Die res van die skors bestaan uit 'n hele aantal lae parenchiemselle met 'n protoplasmatiese inhoud en intersellulêre ruimtes. Sommige van die selle is dikwandig, verhout en besit talryke eenvoudige stippels (fig. 1). In die ou wortel vorm die dikwandige verhoude parenchiemselle 'n meganiese mantel om die endodermis. Hierdie mantel is 'n hele paar sellae breed (fig. 2), en die selle besit talryke eenvoudige, vertakte en onvertakte stippels. In die skors van die ou wortel is ook talryke kleiner selle tussen die groter selle waargeneem. Dit mag moontlik daarop dui dat sommige van die skorsselle verdeel het nadat primêre groei voltooi was, of hulle mag naby die ente waar die selle effens nouer is, gesny wees. Sommige van hierdie klein selle is dikwandig en verhout.

Aan die binnekant word die skors afgesluit deur die endodermis wat een sellag breed is en uit twee soorte selle bestaan. Teenoor die xileemgroepe is die selle dunwandig, behalwe vir hul bande van Caspary in die radiale wande.

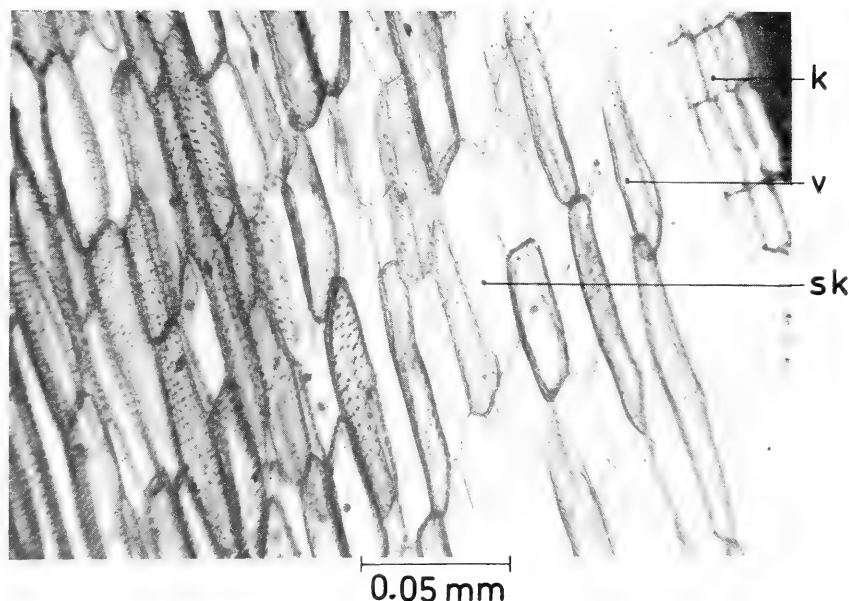


Fig. 1. *Aloe arborescens*. R.L.S. van 'n gedeelte van die buiteskors en die kurklae van 'n ou wortel: k, kurklae; sk, dunwandige skorsselle; v, verhoude parenchiemselle van die skors. Let op die talryke eenvoudige stippels in die verhoude parenchiemselle.

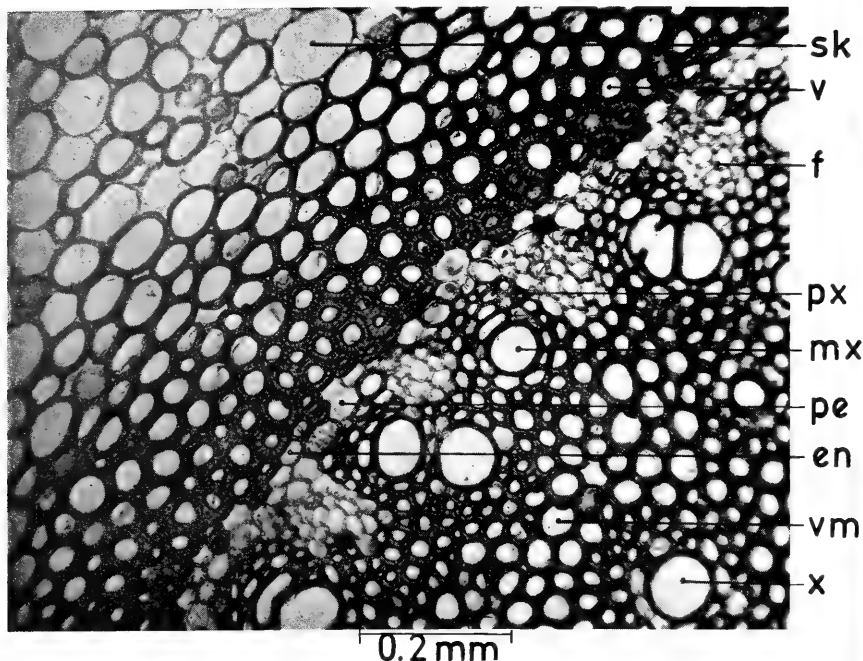


Fig. 2. *Aloe arborescens*. D.S. van 'n gedeelte van die sentrale silinder en die binneskors van 'n ou wortel: en, endodermis met dun- en dikwandige selle; f, floëem; mx, metaxileemvat; pe, perisikel; px, protoxileem-elemente; sk, parenchimatiese skors; v, dikwandige, verhoute parenchiemselle van die binneskors; vm, dikwandige, verhoute parenchiemselle in die grondweefsel van die stele; x, xileemvat, tussen die sklerenchimatiese grondweefsel, wat waarskynlik na voltooiing van primêre groei ontstaan het.

Die ander endodermiselle besit effens verdikte en verhoute binneste tangensiale wande in die jong wortel, terwyl hulle meesal in die tersiêre toestand is in die ou wortel. Beide dun- en dikwandige endodermiselle mag nog 'n protoplasmatiese inhoud besit.

#### Sentrale silinder

Die perisikel is een sellaaq breed. Die selle besit 'n protoplasmatiese inhoud en is dunwandig, behalwe in die ou wortel waar plek-plek die wande van die selle reg voor die xileempole verdik en verhout is. Hierdie wande besit eenvoudige stippels.

Die aantal primêre xileemgroepe wissel tussen sowat 30—40 in die jong wortel en tussen sowat 45—50 in die ou wortel. Die metaxileemvate word

begrens deur dun- en dikwandige parenchiemselle in die jong wortel en deur 'n aaneengeslote mantel van dikwandige verhoude vesels en parenchiemselle in die ou wortel (fig. 2). Elke floëmgroep bestaan uit 3—5 dunwandige sifvate en enkele begeleidende selle. Die sifvate is oënskynlik sonder 'n protoplasmatiese inhoud.

Die sentrale gedeelte van die jong wortel bestaan uit dunwandige parenchiemselle met 'n protoplasmatiese inhoud en intersellulêre ruimtes. Aan die omtrek van die sentrale gedeelte mag sommige selle effens dikwandig en verhout wees.

Die sentrale gedeelte van die ou wortel is baie groot en die grondweefsel bestaan hoofsaaklik uit dikwandige, verhoude parenchiemselle met 'n protoplasmatiese inhoud en talryke eenvoudige stippels. Daar is baie meer sellae as in die jong wortel. Intersellulêre ruimtes kom voor. Hier en daar is ook dunwandige parenchiemselle en dikwandige, verhoude vesels waargeneem. Net soos in die skors kom in hierdie grondweefsel ook verspreide klein selle tussen die groter selle voor (fig. 3). Dit dui daarop dat selverdelings waar-synlik nog plaasgevind het nadat primêre groei voltooi was. Fig. 4 illustreer

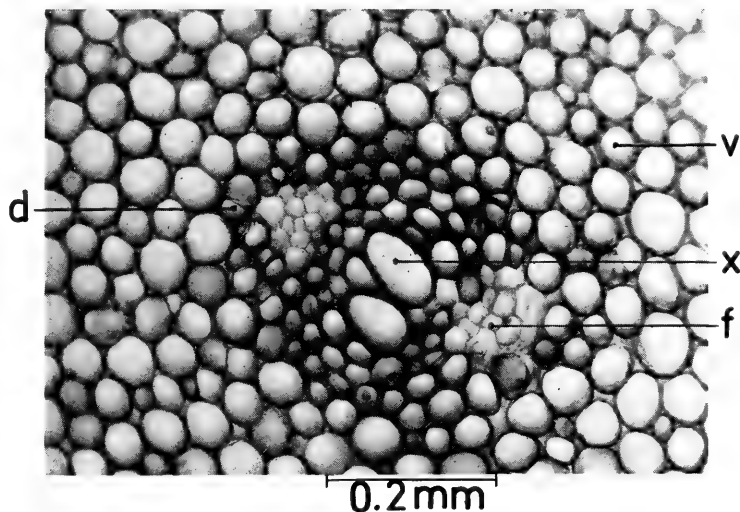


Fig. 3. *Aloe arborescens*. D.S. van 'n gedeelte van die sentrale silinder in 'n ou wortel: d, 'n sel van die grondweefsel wat klaar verdeel het—een van die dogterselle is baie klein; f, floëmgroep; v, dikwandige, verhoude parenchiemsel; x, xileemvat in 'n xileemgroep. Klein selletjies kom oral tussen die groter selle van die grondweefsel voor. Die vaatweefselgroep (bikollaterale vaatbundel) het ontwikkel nadat primêre ontwikkeling voltooi was.

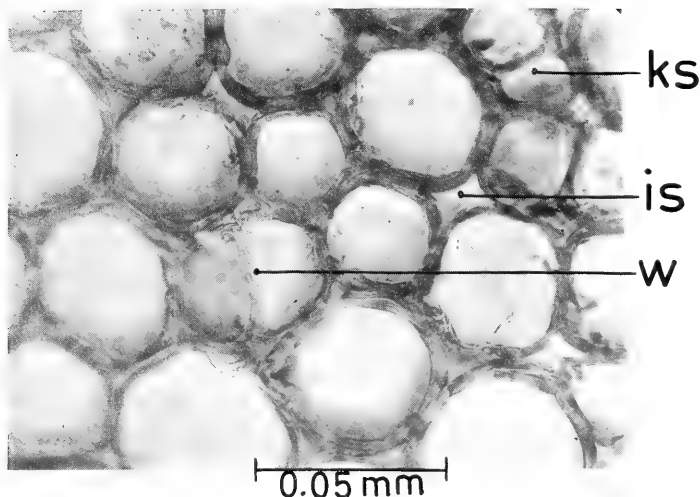


Fig. 4. *Aloe arborescens*. D.S. van 'n gedeelte van die grondweefsel in die sentrale gedeelte van 'n ou wortel: is, intersellulêre ruimte; ks, klein sel; w, dun, onverhoute wand tussen twee pasgevormde dogterselle. Let op die protoplasmatiese inhoud van sommige van die selle en die talryke eenvoudige stippels in die verdikte, verhoute wande.

onder meer 'n sel wat net klaar verdeel het. Die wand tussen die twee dogterselle is dun en nie verhout nie, terwyl die ander wande verdik en verhout is. Sulke selpare is dikwels waargeneem.

Alleenstaande of groepies xileemvate (hoofsaaklik stippelvate) is waargeneem in die sentrale gedeelte van die wortel (fig. 2). Floëmgroepies, bestaande uit dunwandige sifvate en begeleidende selle, kom ook verspreid in die grondweefsel voor. Soms lê die floëem- en xileemgroepies saam in 'n bundel (fig. 3 —'n bikollaterale bundel). Die vaatweefselgroepies word begrens deur dun- en dikwandige parenchiemselle en dikwandige vesels.

Die selle van die sentrale gedeelte van die wortels is nêrens radiaal gerangskik nie.

#### BESPREKING

Die aansienlike deursnee van die ou bywortels van *Aloe arborescens* en die groot mate van verhouting wat by sommige van die weefsels voorkom, dui daarop dat verdere weefselontwikkeling plaasgevind het nadat primêre groei voltooi was. Die groot toename in die deursnee van die wortels kan nie net toegeskryf word aan die ontwikkeling van die periderm of aan selvergroting nie. Die felleem word maar sowat 12 sellae breed en baie min fellodermlae word gevorm.

Die skors- en sentrale gedeeltes van die ou wortel bestaan uit baie meer sellae as dié van jonger dele van dieselfde wortel. Die groottes van meeste van die selle in hierdie twee gedeeltes is in die ou en die jong wortel min of meer dieselfde. Die toename in deursnee van die ouer dele van die wortel mag dus moontlik toegeskryf word aan 'n vermeerdering in die aantal sellae van die skors- en sentrale gedeeltes, nadat primêre groei voltooi was. Hierdie toename in die aantal sellae vind waarskynlik plaas deur individuele verdelings van die parenchiemselle en nie deur die aktiwiteit van 'n bepaalde sekondêre meristeem nie. 'n Kambiumlaag, behalwe by die periderm, is nie waargeneem nie. In teenstelling met wat reeds gevind is by *Dracaena*-soorte, bly die perisikel by *Aloe arborescens* bv. net een sellaaq breed in die ou wortel. Behalwe by die periderm is daar nêrens 'n radiale rangskikking van selle waargeneem nie.

In hierdie verband wil skrywer graag verwys na die bevindings van Tomlinson (1961) in verband met sekondêre diktegroei in die stingels van die Palmae. Hy skryf op p. 20 onder meer: "... several workers ... found that secondary growth was not due to meristematic activity in a restricted region of the stem as in the cambium of dicotyledons, but was the result of overall cell-division and cell-enlargement in the parenchymatous ground tissues, particularly those of the central cylinder, together with the enlargement of the fibres of the vascular bundle sheaths ... This type of secondary activity in palm-stems may be termed diffuse secondary growth."

Meeste van die selle in die ou wortel is baie verhout. Saam met die ontwikkeling van die periderm is die wortel dus struktureel goed aangepas vir 'n lang lewensduur.

Net soos in die geval van *Aloe dichotoma* (Lindinger, 1909) neem die wortels by *Aloe arborescens* aan die einde van primêre ontwikkeling toe in dikte as gevolg van die verdeling van sommige parenchiemselle in die skors- en sentrale gedeeltes, en die daaropvolgende toename in grootte van die dogterselle. Dit stem dus hoofsaaklik ooreen met die "diffuse secondary growth" wat Tomlinson (1961) gevind het by die stingels van die Palmae.

#### OPSOMMING

1. Die wortels van *Aloe arborescens* neem toe in dikte nadat primêre groei voltooi is.
2. Behalwe by die periderm is geen kambiumlaag in die wortels waargeneem nie. Die periderm is ook die enigste weefsel waarvan die selle radiaal gerangskik is.
3. Die skors- en die sentrale gedeeltes word wyer as gevolg van 'n toename in die aantal sellae deur verspreide selverdelings in hierdie streke, gevolg deur 'n vergroting van die dogterselle.

TABEL WAARIN DIE SOORTE MET MEKAAR VERGELYK WORD TEN OPSIGTE VAN BELANGRIKE ANATOMIESE KENMERKE

Soorte gerangskik onder hulle sub- families en tribusse	Bywortels Eenjarig[E] of Meerjarig[M]	Velamen	Periderm	Komplementêre selle	Eksodermis						Dik- wandige selle in die skors	Endodermis			Perisikel	Murg	Besondere selinsluit- tinge						
					Een sellaaq breed	Meer sellae breed	Selle deurgaans effens verdik en verkurk	Deurlaatselle [of klein selle]	Deurlaatselle dunwandig	Deurlaatselle dikwandig		Primer en/of sekonder	Tersier				Een sellaaq breed	Meer sellae breed	Parenchimates	Met xilem	Slym	Tannien	Sekreet [onbekend]
													U-vormig verdik	Rondom verdik									
MELANTHIOIDEAE UVULARIEAE Gloriosa superba . . . . . ANGUILLARIEAE Dipidax triquetra . . . . .	E M	*0 0	0 0	0 0	0 +	0 -	*- +	- +	- -	- -	0 0	0 0	*- +	- -	+	+	- -	+	+	0 0	0 0	0 0	
ASPHODELOIDEAE 45PHODELEAE Bulbinella robusta . . . . . Bulbine caulescens . . . . . B. asphodeloides . . . . . Anthericum galpinii . . . . . Chlorophyllum capense . . . . . Eriosperrum pumilum . . . . . ALOINEAE Kniphofia ensifolia . . . . . Haworthia tessellata . . . . . H. truncata . . . . . Gasteria pillansii . . . . . Aloe arborescens . . . . . A. ciliaris . . . . .	M M M M M M M M M M M M M M M M	+	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	0 +	
ALLOIOIDEAE AGAPANTHEAE Agapanthus campanulatus . . . . . A. caulescens . . . . . A. comptonii . . . . . A. inapertus . . . . . A. orientalis . . . . . A. pendulus . . . . . A. praecox . . . . . Tulbaghia alliacea . . . . . ALLIEAE Allium rotundum . . . . .	M M M M M M M M M M E	+	0 0 0 0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0 0 0 0	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
SCILLOIDEAE Albuca aurea . . . . . Galtonia candicans . . . . . Scilla natalensis . . . . . Eucomis nana . . . . . Ornithogalum hispidum . . . . . Pseudogaltonia clavata . . . . . Veltheimia deasii . . . . . Lachenalia glauca . . . . .	E E E E E E E E	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	0 0 0 0 0 0 0 0	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
DRACAENOIDEAE DRACAENEAE Dracaena hookeriana . . . . . Sansevieria longiflora . . . . .	M M	0 0	0 +	0 0	- -	+	+	+	0 +	- -	- -	0 0	- +	- -	- -	- -	- -	- -	- -	0 0	0 0	0 0	
ASPARAGOIDEAE ASPARAGAEAE Asparagus compactus . . . . .	M	+	0	0	-	+	+	+	-	+	0	+	-	+	-	+	-	+	+	0	0	0	
SMILACOIDEAE Smilax kraussiana . . . . .	M	0	0	0	+	-	-	0	-	-	0	+	-	-	+	-	+	+	-	0	0	+	
Totale . . . . .	8E 27M	9	5	3	29	5	23	25	0	9	2	7	29	11	4	34	1	22	13	7	1	1	

0 = afwesig

- = nie van toepassing nie

+ = aanwesig



4. Die wortel neem dus sekondêr toe in dikte hoofsaaklik as gevolg van die wyerwordende skors- en sentrale gedeeltes.
5. Hierdie soort sekondêre diktegroei mag moontlik na verwys word as „diffuse sekondêre groei”.

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# PARANOMUS.

## A PROTEACEOUS GENUS WITH AN UNFORTUNATE NOMENCLATURAL HISTORY.\*†

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The first species of the genus later known as *Paranomus*, was described by Bergius in 1766 under the name *Leucadendron spicatum*. It was based on a dried specimen collected by Auge and taken to Sweden by Grubb. Four further species were described in the eighteenth century, one by Sparrman and three by Thunberg. The four were assigned to *Protea* which was an omnibus genus at that time. All five eighteenth century species are good and should bear the specific epithets given by their original authors. Unfortunately in more recent times all but one have suffered changes of name.

The trouble began soon after 1807 when the genus *Paranomus* was founded by R. A. Salisbury in William Hooker's *Paradisus Londiniensis*. There he figured and described two species, *Paranomus Sceptrum* based on *Protea Sceptrum Gustavianum* of Sparrman and *Paranomus Lagopus* based on *Protea Lagopus* of Thunberg. The epithet *Lagopus* is retained as Thunberg gave it, but in the second species *Sceptrum Gustavianum* was shortened. Two years later Salisbury modified the latter still further to *sceptriformis*. Clearly stability of nomenclature was not a feature of those days.

Salisbury was a man of peculiar temperament and apparently intensely jealous of the well merited reputation of a rival botanist, Robert Brown, who was at that time engaged on a monumental work on all known Proteaceae. Brown gave a preliminary account of his work at a meeting of the Linnaean Society in January 1809 but publication did not take place till the following year. It is almost certain that Salisbury attended the meeting and must have been aware of the significance of Brown's work. The steps Salisbury took to annoy his rival not only damaged his own reputation but presented problems of nomenclature some of which are as yet unsolved.

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About nine months after the Linnaean meeting a book on Proteaceae appeared, purporting to have been written by Joseph Knight, a nurseryman of Chelsea. Knight was well acquainted with the family for he had at one time been employed as a gardener by George Hibbert, an enthusiastic grower of Proteaceae. It had been Hibbert who at the end of the eighteenth century had sent James Niven to the Cape to bring back dried specimens and seeds for his garden. Thus many South African species of Proteaceae were in cultivation at the beginning of the nineteenth century. The part of the book dealing with cultivation of the Proteaceae was undoubtedly written by Knight but the botanical section was equally certainly the work of Salisbury. From evidence which has come to light since those days, it is now generally accepted that Salisbury was responsible for the names of the species and their descriptions. Hence the authority for the many new species which appear in the book, is now given as "Salisb. ex Knight".

This was an unfortunate start for *Paranomus* and the Proteaceae in general, for some of the species in Knight's work cannot be correlated with those of Brown. Brown's work is so good that there is seldom doubt as to the identity of the species he described. In Knight's book this is certainly not the case for the descriptions are inadequate and suggest hurried preparation. Yet whenever the identity of a species can be established, Salisbury's name, having priority, must be adopted. In the South African sections of both works the species cited are often those collected by Niven whose dried specimens were preserved in well known private herbaria, notably those of Lambert and Hibbert. About the middle of the century, after the owners' deaths, some of these herbaria were sold. No one realised how important they would be to botanists of the future. For example, had Hibbert's herbarium remained intact in some public institution, then many present day difficulties of identification would never have arisen.

Robert Brown evidently liked Salisbury as little as Salisbury liked him. This feeling is reflected in Brown's decision to replace Salisbury's legitimate name *Paranomus* by *Nivenia*, merely because he disliked Salisbury's name. Even had the name *Paranomus* not existed, *Nivenia* could not have been used as it had previously been published by Ventenat for a monocotyledonous genus.

In 1891 the over-zealous Otto Kuntze realised Brown's error and restored the name *Paranomus* to the genus, making numbers of new combinations for Brown's species. As Kuntze had no knowledge of the species with which he was dealing, his work has no particular significance apart from providing a number of new combinations. Thus his name appears as an authority for species about which he was profoundly ignorant.

When in 1912 Phillips and Hutchinson published their account of the Proteaceae in the *Flora Capensis*, they decided to ignore Kuntze and retain

Brown's illegitimate name, a procedure even then contrary to the rules of nomenclature. In a paper published in 1933 N. E. Brown of Kew restored the species to the genus *Paranomus* and drew attention to several problems awaiting solution.

A few examples will illustrate the misfortunes which have attended attempts to identify the species.

***Paranomus spathulatus* (Thunb.) O. Kuntze**

This species was founded by Thunberg in 1781 in one of his dissertations. Under the name *Protea spathulata* it had both a description and a figure. In the Thunberg Herbarium at Uppsala there are two sheets bearing specimens of this species. The specimens of sheet  $\beta$  are good but those on sheet  $\alpha$ , though clearly the same species, are poor.

Juel in his account of Thunberg's Herbarium says that Hutchinson saw these specimens and named  $\alpha$  *Nivenia parvifolia* R. Br. This does not agree with statements in the *Flora Capensis* where both specimens are placed under *Nivenia spathulata* but the figure is assigned to *Nivenia parvifolia*. This figure has been the source of much misunderstanding and calls for comment. If Juel be correct that it was made from a specimen on sheet  $\alpha$ , then the responsibility for subsequent difficulties in nomenclature rests with the artist who depicted slender styles quite unlike any seen in this genus and certainly not appearing on any of Thunberg's specimens. Each slender style is terminated by a knob which has puzzled and misled many. Anyone who has examined Thunberg's specimens is bound to conclude that the artist drew on his imagination when he embellished his drawing in such a manner. It is particularly unfortunate for in this genus a solitary and related species possesses a knob-like ending to the style. The styles of Thunberg's figure have led botanists to assume that it was this species which Thunberg described and not the one to which the specimens belong.

Salisbury in Knight's *Proteaceae* describes a species *Paranomus adiantifolius* for which he cites Thunberg's deplorable figure. Fortunately he also cites a specimen collected by Niven on the mountains near the Rivier Zonder-einde. This is at Kew and settles the identity of Salisbury's species for it has a knob-like pollen presenter, unique in the genus. It is a rare species with a limited distribution at high altitudes in the area where Niven first discovered it. *Paranomus spathulatus* to which it is related, is a fairly common plant on the northern foothills of the Langeberg from Barrydale to the Gouritz River.

Salisbury complicated matters by giving the name *Paranomus flabellifer* to the plant to which Thunberg had applied the epithet *spathulata*. Salisbury based his species on a plant collected by Roxburgh which is clearly the same as the one described many years earlier by Thunberg. The two species and their principal synonymy are as follows:

## PARANOMUS SPATHULATUS (Thunb.) O. Kuntze

*Paranomus flabellifer* Salisb. ex Knight*Nivenia spathulata* R. Br.*Nivenia marginata* R. Br.*Nivenia muirii* Phill. & Hutch.

## PARANOMUS ADIANTIFOLIUS Salisb. ex Knight

*Paranomus spathulatus* N. E. Br. non O. Kuntze*Nivenia parvifolia* R. Br.

A second example of confusion in nomenclature is a tall species reaching six feet in height and little branched. As in the case of *Paranomus spathulatus* it has two kinds of leaf, the upper simple, the lower dissected. It would appear that such a plant would not be easily overlooked. Such, however, is not the case. As far as I know only one botanist of recent times has seen it growing. He was Dr. John Muir, a keen collector in the Riversdale Area. It is likely that it grows in rather inaccessible places. Niven, its discoverer, gave the locality as mountains near the Gouritz River, a place where Dr. Muir found it nearly one hundred years later. It was named *Paranomus longicaulis* by Salisbury in 1809, based on one of Niven's specimens. What is almost certainly the same species was described by Robert Brown in 1810 as *Sorocephalus diversifolius*, also based on a specimen collected by Niven "prope Goud Rivier". The name Goud Rivier was that used by early travellers such as Thunberg and Masson for the river to-day known as the Gouritz River. As Niven's explorations took place but a few years later than those of Thunberg and Masson, it is likely that the name Goud Rivier was still in use and that Niven made use of both names on his field tickets. If so this would dispose of the unwarranted assumption made by N. E. Brown in 1933 that "Goud" was an abbreviation for "Goudini". The assumption was made because what appears to be the only surviving specimen collected by Niven, and now in the British Museum, bears a label on which an old and faded inscription, records that it came from the Roodezand and was given to Mr. A. White by Mr. Niven. The specimen is imperfect and has but one inflorescence below which are entire leaves only. It seems probable that it was left over after better specimens had been presented to large herbaria. There is no doubt that it is the same plant as Muir 3721. It is also the species described by Phillips in 1926 in the Flowering Plants of Southern Africa as *Paranomus diversifolius*.

If this species be correctly placed in *Paranomus*, then the correct name is undoubtedly *Paranomus longicaulis* Salisb. ex Knight. It will be noted, however, that Robert Brown whose judgment was sound, did not place it in *Nivenia* but regarded it as an aberrant form of *Sorocephalus*. In his concept of the genus *Nivenia* Robert Brown laid emphasis on the woody and persistent nature of the bracts in the fruiting heads. This important diagnostic feature has been over-

looked by recent botanists. All the specimens of this particular species at present in herbaria, bear mature but not withered flowers and the bracts of each partial inflorescence are somewhat membranous, giving the impression that they are likely to be deciduous. If this should prove to be the case, then it differs markedly from all other species of *Paranomus* and should be removed from it. It is important that living material be studied so that this critical point can be settled. If the bracts are persistent and become woody then it undoubtedly belongs to *Paranomus* but if this be not so, then a new monotypic genus will probably need to be established for the species does not appear to fit comfortably into *Sorocephalus* to which Robert Brown assigned it.

A group of species in which all leaves are dissected has suffered greatly at the hands of taxonomists. *Paranomus spicatus* was the first of these species to be named. It was founded by Bergius in 1767 as *Leucadendron spicatum*. A little later Thunberg recognised two more species in this group, giving them the names *Protea candicans* and *Protea lagopus*. The specimen in his herbarium bearing the name *Protea spicata* does not belong to the species given that epithet by Bergius but is a duplicate of his species, *Protea candicans*. Robert Brown in 1810 showed a remarkably clear conception of this group and the five species he described are easily recognised by anyone familiar with the genus. He retained two of the old species under the combinations *Nivenia spicata* and *Nivenia lagopus*. He described three new species under the names *Nivenia crithmifolia*, *Nivenia media* and *Nivenia mollissima*. Not one of these may retain Brown's epithets though all are good species. Salisbury's *Paranomus crithmifolius*, published in 1809, is merely a synonym of *Paranomus spicatus*, based on *Leucadendron spicatum* of Bergius. Unfortunately the rules of nomenclature prevent us from using the epithet *crithmifolius* in *Paranomus* in any sense other than that of Salisbury. Another name must be found for this very distinct and common species. There is little doubt that *Nivenia bolusii* Gandoger is this species for it was collected by Bolus near Caledon, a region in which the species is very common. However, the type has not yet been found among Gandoger's plants in Lyon. Bolus noted in his copy of Gandoger's paper that he had not kept in the Bolus Herbarium a specimen bearing the number quoted by Gandoger. If the type be found, the correct citation of this species will be *Paranomus bolusii* (Gandoger) comb. nov. However, with an inadequate description and with the type missing, it seems unwise to make this new combination at the present time. If it be necessary to give the species a new name, a suitable one would be *Paranomus caledonensis* for it is common in the Caledon Division and does not extend far outside its boundaries. *Nivenia media* R. Br. is almost certainly a synonym of *Paranomus bracteolaris* Salisb. ex Knight. It is a common species on the mountain ranges running from van Rhynsdorp

in the north to Porterville in the south. The only doubt arises from the fact that Salisbury published this species as having been collected by Niven on high mountains near Swellendam, a region in which this species has never been found. At Kew there is a specimen collected by Niven and presented by Salisbury to that institution as *Paranomus bracteolaris*. On the ticket accompanying the specimen no precise locality is given, merely the statement that it grew in high alpine situations everywhere. It is therefore probable that the locality published in Knight's work is wrong, one of the unfortunate results of the book's hurried preparation.

*Paranomus abrotanifolius* Salisb. ex Knight, of which the type is at Kew, was assumed to be an undescribed species and given the name of *Nivenia micrantha* Schlechter in 1900. In 1953 it was transferred to *Paranomus* by Compton. However, Niven's type leaves no doubt that it is one of Salisbury's species and must bear the name given at the beginning of this paragraph.

The last of this group of species is *Paranomus candicans* (Thunb.) O. Kuntze, based on *Protea candicans* of Thunberg. Salisbury's *Paranomus argenteus* and Brown's *Nivenia mollissima* are synonyms. *Nivenia laxa* Schlechter which is found on mountains in the Worcester area may also be a synonym for although it lacks the silvery appearance of the typical species, the differences scarcely justify its recognition as a separate species. Sub-specific rank seems more appropriate in which case its citation should be *Paranomus candicans* (Thunb.) O. Kuntze sub. sp. *laxa* Schlechter comb. nov.

A botanist whose work is confined to the herbarium, is almost certain to create unnecessary species in a taxon such as *Paranomus spathulatus*. In the less arid parts of its range it is usual to find on every plant both dissected and entire leaves, the latter showing great variation in form. Under dry conditions the leaves are smaller and the plant may cease to form dissected leaves. In 1962 when studying some dry slopes near the Gouritz River, an area was seen which had been swept by fire the previous season. On it numerous young plants had grown from seed. Some bore dissected leaves only, others bore dissected leaves below and entire leaves above. On a nearly unburnt slope the majority of plants were old and most lacked dissected leaves. It is inevitable that when a species such as this is studied from herbarium specimens only, the number of forms to which specific names are given will be too great. This is the case here. *Nivenia marginata* R. Br. and *Nivenia muirii* Phill. & Hutch. are merely growth forms of *Paranomus spathulatus*. The same is the case in another species, *Paranomus dregei* where a species with rather broad and numerous entire leaves was treated as a new species and named *Nivenia marlothii* by Phillips. Later a new combination, *Paranomus marlothii*, was made for the species by N. E. Brown. This was unfortunate for Marloth was greatly interested in the genus and it would have been fitting to have had his name commemorated in one of



the species. Though the combination *Paranomus marlothii* was made for a non-existent species and by a botanist who had not seen the type, rules of nomenclature prevent its use in any species published subsequently.

In 1810 Robert Brown clearly defined eight species. It is regrettable that when that part of the *Flora Capensis* dealing with the Proteaceae was published over one hundred years later, though Brown's illegitimate name was adopted, his sound conception of both the genus and the species was not appreciated. In the *Flora Capensis* the number of species was increased to thirteen. However only five of them, two new, are entitled to retain the names given them there. Earlier names exist for four species. Two names disappear in synonymy. The remaining two species are hopelessly confused. Under *Nivenia spicata* six distinct species are assembled, not one of which is the species to which Bergius gave the epithet *spicatum* over two hundred years ago. *Paranomus spicatus*, based on Bergius' type, together with two other species, appear under *Nivenia crithmifolia*.

A conservative estimate at the present time is that there are seventeen species of which four are new and as yet undescribed. In a genus of but moderate size it is surprising that so many misfortunes should have attended it since its inception.

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## A NEW ALOE FROM RHODESIA†

L. C. LEACH

Whilst botanising in the Belingwe District of Rhodesia, early in 1965, Mr. E. J. Bullock found some Aloes which appeared to be different from any known to occur in Rhodesia; plants were first seen only on inaccessible, more or less vertical rock faces near Mnene Mission, but were not at that time in flower. Later that year, when the writer accompanied Mr. Bullock to the locality, flowering was over, but the fruiting racemes (seen only through field glasses) obviously belonged in the Section *Anguialoe* Reynolds. As plants in this section were quite unknown in Rhodesia it was decided to make a determined attempt in the following year, to obtain flowering material; in the meantime a few seedling plants were found and placed in cultivation at Bulawayo and Nelspruit,

During the Easter holidays, 1966, an attempt was made to obtain a flowering sized plant, but it was abandoned as being too risky; our rope was too short to reach the base of the cliff and the man power available would have been unable to haul the climber back if anything had gone awry. However, in July, Mr. Bullock and the writer were again in the area, this time with the added objective of collecting material of a Cycad, this accomplished we turned our attention once more to the obtaining of flowering material of our Aloe.

On the road to Belingwe all apparently suitable granite hills were scanned with the field glasses, as we were sure that the species would occur elsewhere in the area. Eventually what appeared to be similar plants were spotted on a bald granite mountain, rising some 600' above the surrounding country. After an easy climb we reached the undulating plateau to find, to our joy, literally thousands of the new species, with many in flower. Photographs were taken and herbarium material prepared, enabling the following description to be drawn up.

**Aloe tauri** Leach, sp. nov.

*A. sessiliflorae* Pole Evans affinis sed planta minore plerumque acaulescenti, saepe habitu frutescenti humilo; foliis brevioribus proportione latioribus, recurvioribus, hieme atropcreis, dentibus marginalibus grandioribus et distantioribus dispositis; pedunculo saepe longiore sed graciliore, non valde sulcato, quam racemo plerumque 2—3-plo longiore; racemo brevior, floribus aliquantum longioribus et nectare aqueo differt.

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Mr. E. J. Bullock examining plants of *A. tauri*, at the type locality, near the summit of "Igar".



Shortly caulescent plant at the type locality, shewing beginning of clump formation.

PLATE 1. *Aloe taurii* Leach.

*Planta* solitaria vel in catervis grandibus caespitosa, acaulescens vel caule brevi plerumque procumbenti, 5—7 cm diam., propagulis e basi vel ex parte procumbenti, raro erecto, infrequenter altiore quam 30 cm. *Folia* c. 25, dense rosulata, anguste ovato-attenuata, 34—55 cm longa, basi 6—8 cm lata, patulo-recurva vel valde recurva, supra saturato-flavoviridia, margines versus rubiginosa, hieme mox uniformiter cupreo-rubra, basi plana vel leviter concava, superne canaliculata, subtus convexa; *margines* ferruginei, dentibus ferrugineis pungentibus uncinatis saepe apicibus atro-brunneis, 2—3 mm longis, 6—15 mm distantibus armati. *Inflorescentia* ad 1 m alta, simplex vel perrariter ramulo unico; *pedunculus* ascendens, teres, atropurpureo-brunneus, satis glabrus, perleviter sulcatus, ad 60 cm longus, proportione gracilis, basi plano-convexus, marginibus lateralibus acutangularibus, ad 1.5 cm latus, deinde teres c. 1 cm diam.; *bracteis* sterilibus numerosis, ovato-acuminatis vel ovato-acutis, 3—5 nervatis, c. 12 mm longis, 6—7 mm latis vestitus. *Racemus* cylindricus, plerumque c. 20 cm longus, 5—6 cm diam. dense sessiliflorus aureus, floribus nectare aqueo semi-impletis. *Bracteae* scariosae, nervis brunneis 3—5, ovato-acuminatae, 10—12 mm longae, 7 mm latae. *Pedicelli* nulli. *Perianthium* campanulatum, 15—18 mm longum, basi 4—5 mm diam., ad orem 9—15 mm diam.; *segmenta exteriora* ad basem libera candido-translucencia, intra versus apicem flavescencia; nervis 3, viridulis vel viridi-flavis, apicem versus confluentibus; *segmenta interiora* latiora, obtusiora, nervis 3, incrassatis in carinam 3-costatum formatis. *Filamenta* aureola recta; *antherae* armeniacae, deinceps 7—10 mm exsertae. *Ovarium* brunnescens oblongo-ellipsoideum, c. 5 mm × 3 mm. *Stylus* basi brunnescens, versus apicem flavescens, *stigma* demum 10—13 mm exserto. *Capsula* oblongo-ellipsoidea basi aliquantum truncata, sessilis, floris induviis ad basem firme affixis, brunnea haud viridula, ad 15 mm longa, 7.5 mm diam. *Semina* irregulariter triquetra, angulis margine membranaceo instructis, fuliginea minutissime lenticulari-pusticulata.

Type: *Leach & Bullock* 13321 (BM; G; K; LISC; PRE; SRGH, holotype).

RHODESIA. S: Belingwe Distr., prope Mnene Mission, cult. Bulawayo, fl. vii. 1966, *Bullock* 52—5 (BM; SRGH), ibid, cult. Nelspruit, fl. vii. 1966, *Leach & Bullock* 12872 (K; PRE); "Igar", Mweza Ra., c. 29° 49' E, 21° 01' S, fl. 11. vii. 1966, *Leach & Bullock* 13321 (BM; G; K; LISC; PRE; SRGH). Nuanetsi Distr., Matibi Res., "M'shunga Nibure", fl. 24. vi. 1967, *Cannell* 34 (SRGH), ibid., fl. 1. vii. 1967, *Leach & Cannell* 13797 (K; PRE; ZSS).

The specific epithet is in honour of the discoverer of the new species, Mr. E. J. Bullock of Bulawayo, Rhodesia. Mr. Bullock is a keen student of the genus *Aloe* as it occurs in Rhodesia and has made a number of contributions to our knowledge of the species and their distribution in Rhodesia.



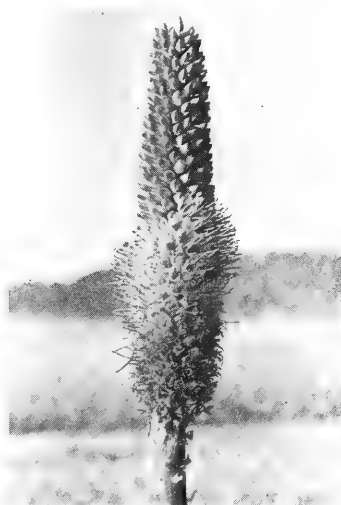
Cult. Bulawayo. Ht.  $\pm 1$  m.



Cult. Nelspruit. Ht.  $\pm 1$  m.



*A. tauri* — *A. sessiliflora*,  
A comparison.



Raceme of above plant,  $\pm 20$  cm long.

The type locality of our new species: Igar Mountain, 3972', lies at the south-western end of the Mweza Range, about 30 miles east of West Nicholson. From about 3500' *A. tauri* becomes the dominant species; at the lower limit it is associated with masses of *Euphorbia griseola* Pax. Plants are plentiful on all aspects, in dense masses amongst tussock grasses in shallow humus-filled hollows or hanging on almost vertical rock faces. It seems amazing that these plants in their thousands should have escaped notice for so long in a country as relatively well collected as Rhodesia.

Field glasses enabled us to see what appeared to be another colony on a nearby hill, although identification is not certain. It is thought to be probable that the species will be found to occur at other points more or less along the hills stretching to the east, towards Triangle and Chiredzi. A further colony has already been found by Mr. I. C. Cannell on "M'shunga Neburi" (God's needle) in the Matibi Reserve, some 60 miles to the east of Mt. Igar, here it is associated with *A. aculeata* Pole Evans and *A. chabaudii* Schönl. as well as with *E. griseola*. Mr. N. Bey also reports what appears to be a natural hybrid with *A. aculeata* from the same locality; he has also found, in the vicinity, plants which are almost certainly, although sterile, identifiable as *A. cameronii* Hemsl.; if confirmed, this will considerably extend the known distribution of this latter species.

*Aloe tauri* belongs in Section *Anguialoe* Reynolds, and is the sixth species in this section, which was set up in 1940 to accommodate this most distinctive and closely related group, of which the type is the widespread *A. sessiliflora*.

The new species fits into Reynold's keys as follows:

"Aloes of South Africa": 428 (1950).

#### Section 5: *Anguialoe* Reynolds

##### A. Flowers sessile

##### (1) Stem short, procumbent

- (a) Leaves spreading, glaucous green. *Perianth* 18—20 mm, rose coloured with dark brown nectar . . . . . *A. vryheidensis*
- (b) Leaves recurved, dark yellowish green, coppery red in winter, *Perianth* 15—18 mm, yellow with crystal clear nectar. *A. tauri*

"Aloes of Tropical Africa and Madagascar": 241 (1966).

#### Group 15

##### A. *Racemes* (15) 30—50 cm long, erect

- (1) Leaves arcuate-incurved, *Perianths* cylindric-ventricose, orange, 36 mm long . . . . . *A. aculeata*
- (2) Leaves spreading. *Perianth* red, up to 40 mm long, cylindric-ventricose . . . . . *A. rubroviolacea*

- (3) *Leaves* recurved. *Perianth* yellow, up to 18 mm long,  
 campanulate . . . . . *A. tauri*

The new addition is the smallest in the section and is characterised by its simple inflorescence of short, densely flowered, cylindric racemes of bright yellow flowers, borne erect on slender ascending peduncles which are 2—3 times as long as the racemes. In size of flowers and length of raceme it is nearest to *A. vryheidensis* Groenewald, but in leaf characters and in many other respects it is entirely different. It seems that the nearest relationship is with *A. sessiliflora*, from which it differs in being a much smaller, usually acaulescent, clump-forming plant with proportionately broader more recurved leaves with larger more widely spaced marginal teeth. However, the most striking difference lies in the previously mentioned peduncle—raceme proportions. In *A. sessiliflora* these are, on average, about equal in length, whereas in *A. tauri* the short racemes are only one third to half the length of the slender, lightly sulcate peduncles. The flowers of the new species are slightly longer and tend to be more open than those of its closest relative, and appear to be of a much brighter hue, this latter, is due, in part no doubt, to the absolutely clear nectar which half fills the flowers; *A. tauri* is the only species in the section with this crystal-clear nectar, that of *A. alooides* (Bolus) Van Druten, alone approaching it in its pellucidity.



*Aloe tauri*: flowers 1/1.

Some of the differing characteristics are tabulated below:

	<i>A. tauri</i>	<i>A. sessiliflora</i>
Peduncle length	52·3 (48—60)	46·6 (32—57)
Raceme length	21·7 (15—30)	45·6 (38—50)
Ratio		
Peduncle/Raceme	2·5 (1·95—3·5)	1·05 (0·68—1·35)



Perianth length	15—18 mm	14—15 mm
Leaf dimensions	41 × 7 (34—55 × 6—8)	71 × 9.5 (59—84 × 7.5 × 10.5)
Ratio		
Leaf length/width	5.9 (5—6.9)	7.5 (6—9.4)

All measurements in cm (except perianth); averages (in heavy type) to nearest decimal point; maxima and minima in brackets. Compiled from measurements taken from natural populations on Igar Mtn., Rhodesia, and Nelspruit, Transvaal, respectively.

*Plant* solitary or forming large clumps, acaulescent or with a short, usually procumbent stem, 5—7 cm diam., with offsets from the base or along the procumbent portion, seldom erect and only occasionally more than 30 cm high. *Leaves* about 25, densely rosulate, narrowly ovate-attenuate, 34—55 cm long, 6—8 cm broad at the base, spreading to spreading-recurved (often strongly recurved) only very occasionally nearly straight (apparently when in particularly moist situations); *upper surface* dark yellow-green, dull red towards the margins, becoming a uniform coppery red at the onset of winter, flat or slightly concave towards the base, becoming canaliculate towards the apex; *lower surface* rounded, green becoming red; *margins* pinkish brown, armed with similarly coloured (often dark brown tipped) pungent, hooked teeth, 2—3 mm long, 6—8 mm apart low down with rounded interspaces, becoming more widely spaced, 8—15 mm, with straight interspaces above. *Sap* dries yellow. *Inflorescence* simple or very rarely 1-branched, usually only one from a rosette (occasionally two), up to c. 1 m high; *peduncle* ascending, up to 60 cm long, rather slender, terete, c. 1 cm diam. above, somewhat flattened on the inner face below, up to 1.5 cm wide with hard acute lateral margins, quite glabrous, very lightly longitudinally sulcate, dark purplish brown (dark green on portions in heavy shade); *sterile bracts* numerous, scarious, brownish cream, ovate-acuminate or ovate-acute, 3—5 nerved, c. 12 mm long, 6—7 mm wide. *Raceme* cylindric, 15—30 cm long (generally c. 20 cm), 5—6 cm diam., very densely multi-flowered, bright yellow, the sessile flowers half-filled with crystal-clear nectar. *Bracts* scarious brownish cream, ovate-acuminate, 10—12 mm long, 7 mm wide, with 3—5 brownish nerves. *Pedicels* none. *Perianth* campanulate, 15—18 mm long, 4—5 mm diam. at the base, up to 15 mm diam. at the open mouth; *outer segments* free, translucent-white, yellow or somewhat orange at the apex inside, with 3 yellow-green nerves (sometimes brownish or salmon-red) confluent towards the apex; the lower segment straight, the two lateral with the apex slightly curved upwards; *inner segments* broader and thinner than the outer with the more obtuse apex sometimes shortly and sharply revolute, pale translucent-yellow with the 3 greenish-yellow, confluent nerves raised and thickened into a ribbed keel. *Filaments* filiform flattened, orange-yellow becoming pale greenish-yellow at the apex, the

3 inner narrower and lengthening before the 3 outer, straight, more or less evenly distributed around the mouth of the perianth. *Anthers* bright orange, in turn exserted 7—10 mm. *Style* brownish-orange at the base to yellow at the apex; *stigma* at length exserted 10—13 mm. *Ovary* sessile, brownish-orange, oblong-ellipsoid, somewhat truncate at the base, c. 5 mm  $\times$  3 mm. *Capsule* sessile, with the withered remains of the flower firmly attached to its truncate base, oblong-ellipsoid, up to 15 mm long, 7.5 mm diam., 3.5—4 mm diam. at the base, brown, not at all green at any stage. *Seeds* generally irregularly trigonous, occasionally tetragonous, very rarely pentagonous, c. 3.25—4.25 mm long, blackish brown, flecked with minute lenticular pustules, with translucent membranous whitish margins on the angles.

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Mr. E. J. Bullock, for conducting me to the Mnene Mission locality, for his assistance on the excursion when *A. tauri* was located on Igar Mtn. and on many other botanising trips together and for plants and information regarding them, from many parts of Rhodesia.

Mr. I. C. Cannell, for taking me to the hill "M'shunga Neburi" and for photographs and material of *A. tauri* from that locality.

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Mr. R. B. Drummond, Chief Botanist, Government Herbarium, Salisbury, for the facilities of the herbarium.

The late Dr. G. W. Reynolds, who was my mentor in all matters pertaining to the genus *Aloe*, over many years, for photographs and many plants from tropical Africa and elsewhere, some of which have yet to be described.

# STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: V

*Fimbristylis* species of sections *Fimbristylis*, *Dichelostylis* Benth, and  
*Pogonostylis* (Bertol.) Pax.†

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## ABSTRACT

Descriptions, illustrations, and citations of representative Southern African and some Tropical African specimens of *Fimbristylis dichotoma*, *F. bisumbellata*, *F. squarrosa*, *F. ferruginea* and *F. longiculmis* are given. The occurrence of natural, sporadic interspecific hybrids between some pairs of these species is reported. The relationships of the species to one another are discussed and a key to identification provided.

## INTRODUCTION

The species of *Fimbristylis* Vahl considered in this paper are *F. dichotoma* (L.) Vahl, *F. bisumbellata* (Forsk.) Bub., *F. ferruginea* (L.) Vahl, *F. longiculmis* Steud. and *F. squarrosa* Vahl. Kern (1955), in dealing with Asian Cyperaceae, referred the first two of these to the type section, *Fimbristylis*, characterized by spiral glumes, flat usually fimbriate, two-branched styles, trabeculate biconvex achenes, and leaves with the ligule either membranous or consisting of a dense fringe of short hairs. *F. ferruginea*, closely related, yet differing in the smooth, non-trabeculate achene, he placed in *Dichelostylis* Benth., while *F. squarrosa* was included within *Pogonostylis* (Bertol.) Pax, a section comprising plants without ligules and with small, angular spikelets. *F. longiculmis*, at present known only from Malagasy and Africa, was not considered, but because of close floristic relationships, it is best placed in *Dichelostylis* with *F. ferruginea*.

The descriptions and citations that follow are as in previous papers in this series (Gordon-Gray, 1966a, b).

**3. *Fimbristylis dichotoma*** (L.) Vahl in Enum. Pl. 2: 287 (1806); Fischer in Bull. Misc. Inf. 1935: 149 (1936); Hutch. in Fl. W. Trop. Afr. II (2): 474 (1936); Kern in Blumea 8 (1): 155, 160 (1955); Robyns & Tournay in Fl. des Sperm. du Parc Nat. Albert 3: 260 (1955); Koyama in Journ. Fac. Sci. Univ. Tokyo III 8 (3): 111 (1961); Podlech in Prod. Südwestafrika 165: 23 (1967).

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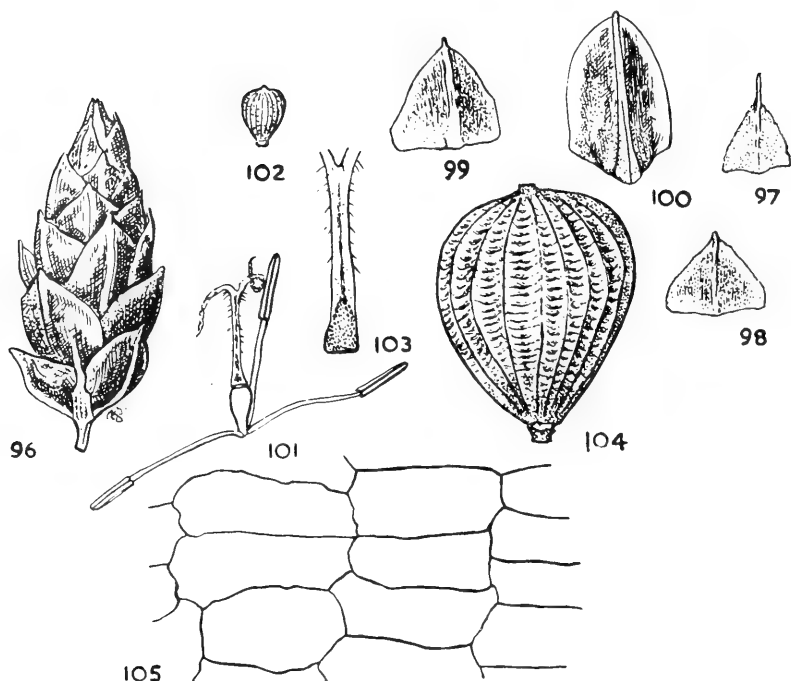


FIG. 8. *Fimbristylis dichotoma* (L.) Vahl (Ward 1678).

96—spikelet; 97—99—three lowest glumes of spikelet; 100—fifth glume from spikelet base; 101—young floret; 102—achene (all  $\times 7$ ); 103—style base and style ( $\times 14$ ); 104—achene ( $\times 28$ ); 105—epidermal pericarp cells ( $\times 196$ ).

*F. diphylla* (Retz.) Vahl in Enum. Pl. 2: 289 (1806); Nees in Linnaea 9: 290 (1834) name only; Bak. in Fl. Maurit.: 418 (1877) syn. *F. rigidula* excl.; Clarke in Fl. Brit. Ind. 6: 636 (1893) and in Dur. & Schinz, Consp. Fl. Afr. 5: 603 (1895); K. Schum. in Engl. Pfl. Ost. Afr.: 124 (1895); Clarke in Dyer Fl. Cap. 7: 200 (1893); Rendle in Cat. Afr. Pl. Welw. 2: 122 (1899); Clarke in Dyer Fl. Trop. Afr. 8: 417 (1902) and in Bull. Misc. Inf., Addit. Ser. 8: 107 (1908) name only and in Illus. Cyp. t. XLII f. 1, 2 (1909); Burtt Davy & Leerndertz-Pott in Ann. Tvl. Mus.: 132 (1912) name only; Eyles in Trans. Royal Soc. S.A.: 315 (1916) name only; Schonl. in S.A. Cyp., Mem. Bot. Survey S. Afr. 3: 33 (1922); de Wild. in Pl. Bequaert. 4: 201 (1927); Cherm. in Cat. Pl. de Madag. Mem. Acad. Malgache: 31 (1931); Brain in Proc. Rhod. Sc. Assoc. 33: 84 (1934); Peter in Fedde Rep. 40: 400 (1936-7); Cherm. in Fl. de Madag.

Cyperaceae: 178 (1937). *F. communis* Kunth in Enum. Pl. 2: 234 (1837) syn. quibusdam excl.; Ridl. in Trans. Linn. Soc., Ser. II, Bot. 2: 150 (1884) partly. *F. sechellensis* Bak. in Fl. Maurit: 418 (1877).

*Scirpus dichotomus* L. in Sp. Pl. ed. 1: 50 (1753); l.c. ed. 2: 74 (1762). *S. diphyllus* Retz. in Obs. Bot. VI: 15 (1791).

*Fimbristylis dregeana* Kunth in Enum. Pl. 2: 232 (1837) *Fimbristylis*  $\times$  *dregeana* Kunth (pro species).

*Annual*, occasionally biennial or perennial, erect, up to 126 (usually 60–70, sometimes 28 or less) cm in height, sparsely tufted, sterile shoots infrequent: *rhizome* visible only when shoots broken apart, up to 5 mm wide, persistent leaf bases usually lacking; *leaf sheaths* well developed, terete, entire, splitting from mouth in age, glabrescent to densely white pilose (indumentum always better developed in upper half), keel generally rounded, many nerved, green to cream, membranous portion conspicuous when dry, nerveless, pallid to golden brown, usually darker speckled, mouth truncate, ciliate; *ligule* a dense fringe of white hairs; *blades* always developed, up to 36 cm long,  $1.3\text{--}4.1$  ( $2.45 \pm 0.15$ ) mm wide, linear, herbaceous, glabrous adaxially, glabrescent abaxially, margins thickened to ridged, generally slightly involute, closely scabrid pubescent to smooth, apex obtuse occasionally broadly acute, scabrid: *flowering stems* erect, terete to slightly flattened especially below inflorescence, sparsely white pilose especially on angles and below inflorescence, occasionally glabrous: *inflorescence* up to 15 cm long, up to 10 cm wide, a compound “umbel” (anthela, Rickett, 1944) of  $\pm 73$  spikelets, often reduced, sometimes markedly so forming a simple “umbel” of  $\pm 3$  spikelets; *pedicels* up to 6 cm long, markedly flattened, glabrous, angles scabrid or smooth; *bracts* 2–4, usually 3, leaflike, generally equalling, occasionally shorter than or far exceeding inflorescence, sheaths densely white pilose, mouth faintly white ciliate, blades white pilose to scabrid pubescent: *spikelets* 4–11 ( $7.13 \pm 0.41$ ) mm long, 2–3 ( $2.69 \pm 0.09$ ) mm broad, compact, cylindric, scarcely angled by glume keels, elliptic to elliptic lanceolate when young, lanceolate ovate in age, acute, occasionally almost obtuse, shining chestnut brown with lighter markings, basal glumes early deciduous; *rachilla* straight, deeply notched, usually showing spiral arrangement of glumes, ragged due to persistent, acute, dark brown wings with pallid apices; *glumes*, lowest 1–2 sterile, bract-like, remainder fertile, 2.0–3.5 ( $2.95 \pm 0.06$ ) mm long, 1.7–3.3 ( $2.66 \pm 0.08$ ) mm in total width, broadly ovate to orbicular, shining chestnut red paling towards narrow membranous margin, glabrous, keel well defined, slightly projecting, of 3 veins excurrent into mucron, apex rounded, mucronate: *stamens* 3; *anthers* 0.7–1.1 ( $0.84 \pm 0.02$ ) mm long, yellow, crest minute, smooth, brownish: *style* 1.6–2.1 mm long including style base, 0.15–0.28 ( $0.2 \pm 0.01$ ) mm wide at narrowest point, ribbon-like, flattened in plane of achene, 3 nerved, margins long villous, style base

slightly wider than style; branches 2, shorter than style, flattened in plane of achene, tapering apically, margins fringed, hairs shrivelling with age: *achene* 0.9—1.24 ( $1.14 \pm 0.02$ ) mm long, 0.65—0.95 ( $0.76 \pm 0.02$ ) mm broad, biconvex, obovate to almost orbicular, apex minutely projecting, cream to yellow to dark brown-black eventually, surface with 6–9 prominent longitudinal ridges, trabeculate; gynophore just developed; *outermost cells to pericarp* transversely elongate, placed in longitudinal series, eventually velate (giving temporarily a white coloration to achene).

*Flowering period*: November to March inclusive.

TYPE: *Scirpus dichotomus* Linn. Sp. Pl., ed. 1: 50 (1753) is based on, “*Gramen parvum . . .*,” Herm. Zeyl.: 26 (1737) and “*Gramen Cyperoides Maderaspatanum, Juncelli Gesneris . . .*,” Pluk. Alm.: 179, t. 119, f.3 (1705). The types of both Plukenet and Hermann are preserved at the Herbarium of the British Museum of Natural History, London. They are identical (Fischer, 1936). Plukenet’s specimen, from India, is selected the lectotype of the species.

#### SELECTED CITATIONS

SUDAN. Seriba Ghattas, *Schweinfurth* 1464 (NH); Tinor River, *Schlechter* 6392 (GRA).

IVORY COAST. c. 115 km n. of Tabou on rd. to Tai, *de Wilde* 3596 (PRE).

GHANA. 2 ml. n.e. of Kwahu Tafo on rd. to Adawso, *Rose Innes* 30580 (PRE).

TOGO. prope Lome, *Warnecke* 138 (EA).

CONGO. National Albert Park, Volcano Rumoka 1,600 m. *Germain* 3681 (PRE); Plaine Rusizi, region de Luberisi, mont Kalambo, *Germain* 6286 (PRE).

UGANDA. Napak, Karamja, *Thomas* 3602 (EA); Bukedea, Bugwere, *Thomas* 3855 (EA); Serere, Teso, *Chandler* 723 (EA); 2 ml. along Gayaza rd. *coll. for Snowden* 2108 (EA); near Banda, *Dümmer* 1380 (PRE).

KENYA. Bukura, North Kavirondo, *Graham* 213 (EA).

TANZANIA. Mafia Island, Kilindoni, *Greenway* 5248 (EA, PRE); Morogoro distr: Bwakira-ya-ju, *Haarer* 1844 (EA); Hagga distr: Kilimandjaro Süd c. 1,500 ft. *Schlieben* 4611 (PRE); Moshi distr: Usangi, Upare, *Haarer* 814 (EA); Rufiji distr: without precise locality, *Musk* 112 (EA); Tanga distr: Amani, *Verdcourt* 175 (EA, PRE); Usaramo distr: Usambara, *Holst* 3743 (EA); districts unknown: Unyamwesi, Komba os Alich to Kaliuwa, *Peter* 35717 (EA); without precise locality: *Zimmerman* 7584 (EA).

ZAMBIA. Mweru distr: Chamfubu plain, Lake Mweru, *Vesey-Fitzgerald* 539 (RLCS); Alungu distr: Abercorn, Lake Chila, *Seagrief* 2281 (PRE); Kasama distr: Mungwi, *Robinson* 4072 (PRE, EARO); Mwinilunga distr: by river Matonchi, near garden, *Milne-Redhead* 2910 (PRE); Central distr:

Mkushi, Fiwila, *Robinson* 2716 (PRE, EARO); Mazabuka distr: Mazabuka, Simasunda, *Robinson* 2144 (NU, PRE); Batoka distr: Livingstone, n. bank of Zambesi river, *Rogers* 13004 (BOL).

MALAWI. Nyasa distr: Likubula Gorge, *Brass* 16386 (PRE); Banks Rukuru river, near lake, *Leech* 9 (PRE).

MOZAMBIQUE. Portobelo distr: Quelimane, *Sim* 20747 (NU); Zambesia: Island Jagarra, *Gomes Pedro* 2171 (LMJ); Buzi distr: Beira, *Rogers* 5947 (GRA, BUL); Chimoio distr: entre Pavua e Vila Pery, *Pedro & Pedrogao* 221 (LMJ); Dombe distr: entre Dombe e Mapira, a 18 km do Posto, *Gomes Pedro* 4453 (PRE); Sabie distr: Namaacha, *Grandvaux Barbosa* 76 (LM).

RHODESIA. Lomagundi distr: eastern Urungwe, *Phipps* 1001 (PRE); Salisbury distr: near Salisbury, Rua river, *Eyles* 1441 (SRGH, PRE); Wankie distr: Victoria Falls, rain forest, *Robinson* 1047 (EARO); Hartley distr: Hartley, Poole Farm, *Hornby* H2436 (SRGH); Marandellas distr: Marandellas, Grasslands Research Station, *Colville* 64 (SRGH, J); Makoni distr: Makoni, *Eyles* 2941 (PRE, SRGH, GRA); Inyanga distr: Inyanga, Chisire, Nyarakokwa river, *Norlindh & Weimarck* 4301 (PRE, BUL); Nyamdhlovu distr: Matundhlamhla vlei, *Pardy* 47 (SRGH); Melsetter distr: Melsetter, *Otterson* 38 (SRGH); Matobo distr: farm Quasinga, *Miller* 5239 (PRE).

SOUTH WEST AFRICA. E. Caprivi, Zipfel, about 8 miles from Katima Mulilo on road to Ngoma, *Killick & Leistner* 3042 (PRE); Damaraland, Waterberg Plateau, *Boss* s.n. (PRE).

BOTSWANA. Without precise locality, *Curson* 218 (PRE).

TRANSVAAL. Zoutpansberg distr: farm Zoutspan, *Obermeyer, Schweickerd & Verdoorn* 221 (PRE); Potgietersrust distr: Pyramid Estate, near Potgietersrust, *Galpin* 9106 (PRE, GRA); Pietersburg distr: Houtbosch, *Rehmann* 5623 (K, BOL); Waterberg distr: About 17 miles from Vaalwater on road to Hermanusdoorns, *Meeuse* 10525 (PRE); Letaba distr: Westfalia, confluence of Mtati and Ramadiepa rivers, *Scheepers* 381 (PRE); Lydenburg distr: farm Zwagershoek, *Obermeyer* 266 (PRE); Brits distr: Magaliesberg, Wolhuter's Kop area, *Killick* 1994 (PRE); Pretoria distr: 10 miles n.e. of Hammanskraal on Premier Mine rd, *Codd* 3513 (PRE); Belfast distr: Waterval Onder, *Jenkins* 6886 (PRE); Nelspruit distr: Nelspruit, *Breyer* s.n. (PRE); Krugersdorp distr: farm Gladysvale near Krugersdorp, *Rodin* 3852 (PRE).

SWAZILAND. Mbabane distr: Mbabane, *Rogers* 11625 (BOL); Boundary between Mbabane and Manzini distrs: Malkerns, *Compton* 27363 (SGH); Manzini distr: Little Usutu river, *Compton* 28469 (SGH); Mankiana distr: Mankiana village, *Gordon-Gray* 6015 (NU, SGH); districts unknown: Komati Pass, *Compton* 31301 (SGH, PRE); Kirkhill, *Compton* 25757 (SGH, PRE).

NATAL. Ingwavuma distr: n.e. Lake Sibayi, *Tinley* 92 (NPGF); Newcastle distr: Cundy Cleugh Pass, *Skead & Ward* 8 (NPGF, NU); Vryheid distr:

Hlobane, *Johnstone* 341 (NU, PRE); Hlabisa distr: Hluhluwe Game Reserve, *Ward* 1678 (NPGF, NU); Dundee distr: 5 miles e. of Sundays river on Helpmekaar road, *Edwards* 2380 (PRE, NU); Klip River distr: Klip river near Wessel's Nek, *Acocks & Pentz* 10257 (NH, PRE); Bergville distr: Cathedral Peak Forestry Station, Mlambonja Valley, *Killick* 2343 (PRE); Estcourt distr: Monk's Cowl, Cathkin, *Killick* 2323 (PRE); Eshowe distr: Umlalazi, *Medley Wood* s.n. (NH); Mtunzini distr: Port Durnford Lighthouse, *Ward* 4011 (NPGF, NU, PRE); Mapumulo Distr: Umvoti Valley, s.w. of Mapumulo, *Moll* 1576 (NU, PRE); Lion's River distr: Balgowan, Glen Arum, *Mogg* 3853 (PRE, GRA); New Hanover distr: Albert Falls, *Comins* 223 (NU); Pietermaritzburg distr: Pietermaritzburg, Town Hill, *Huntley* 502 (NU, M); Camperdown distr: Nagle Dam, *Wells* 1277 (PRE, NU); Durban distr: near Durban, *Medley Wood* 6012 (NH); Umlazi distr: Louis Botha Airport area, Reunion, *Bayer* s.n. (NU); Port Shepstone distr: Oribi Flats, *McClean* 388 (PRE, NU); without precise locality: *Buchanan* 81: 118: 339 (K); *Buchanan* 338 (PRE); *Bews* 38 (NU).

CAPE PROVINCE. Umzimkulu distr: near Clydesdale *Tyson* 1191 (NBG, BOL, K); Bizana distr: near Sea View on Port Edward—Redoubt road, *Huntley* 763 (NU); Port St. John's distr: Isinuka, Flanagan 2609 (NBG, PRE); Mqanduli distr: Tembuland, Umtata river below 1,000 ft. *Drège* s.n. (K); Kentani distr: Kentani, *Pegler* 1090 (GRA, BOL, NBG).

In Africa the species is also known to occur in Angola (Rendle, 1899), but no specimens from this province have been seen.

## WORLD DISTRIBUTION

MALAGASY. Ambohimanga pries du Tananarive, *Bosser* 13792 (PRE); Gorges du Manambolo, *Decary* 7902 (PRE); Analabe (N. de Tananarive) *Bosser* 5182 (PRE).

The species is also known from Mauritius, India, Malaysia, China, Japan, N. Australia, Polynesia, the Sandwich Islands, Tropical and Temperate America and Southern Europe. Clarke (1898) reported that it was to be found in, "All tropical and warm temperate regions."

It is not surprising that so abundant and widespread a sedge should be listed as a weed and should have had, when most narrowly diagnosed, some 140 names applied to it (Clarke, l.c. p. 201). Many infra-specific taxa have been recognised within *F. dichotoma* to which Koyama (1961) added a subspecies and a variety.

In Southern Africa, *F. dichotoma* is commonly to be found, from mid to late summer, in the damp mud of river and stream-banks, vleis and seepages and the damp washes of drainage ditches along roadsides. Isolated plants, never forming dense stands, are occasional in damp grassveld, sometimes far



from the nearest streamlet or vlei. Such plants are usually shorter and more compact than those occupying more hygrophilous situations in which there is greater competition for light among taller associates: their inflorescences are also often markedly reduced in size, degree of branching and number of spikelets.

In early spring, in areas where in summer it is in abundance, *F. dichotoma* can be detected only by the presence of the previous year's inflorescences that remain attached to the old plants, a few only of which survive. Achenes germinate in quantity among the dead plants producing seedlings that are flowering within three to four months.

Brain (1934) stated "... the fertile glumes appear white margined owing to the presence of cilia." Occasionally the sterile glumes develop a few short hairs forming a poorly defined ciliate fringe; otherwise margins are uniformly glabrous, but an extremely narrow pallid membranous margin gives the impression of a white edged glume.

Clarke (1898) cited Rehmann 7714 as from Houtbosch, Transvaal, but stamped on the sheet is "Natal—Camperdown."

Kunth (1837) described *Fimbristylis dregeana* (type Drège, between Umtentu and Umzimkulu Rivers, Pondoland, Transkei) which, apart from slightly broader more shining spikelets, shows close affinity with *F. dichotoma*. Detailed study revealed characters relating Kunth's type to other specimens regarded as putative hybrids between *F. dichotoma* and *F. ferruginea*. These are dealt with later in this paper.

**4. *Fimbristylis bisumbellata* (Forsk.) Bub.** in Dodec: 30 (1850); Fischer in Bull. Misc. Inf: 149 (1935); Hutch. in Fl. W. Trop. Afr. **II** (2): 476 (1936); Nelmes & Bald. in Am. Jour. Bot. **39** (6): 377 (1952); Kern in Blumea **8** (1): 135 (1955); Koyama in Journ. Fac. Sci. Univ. Tokyo **III**, 8 (3): 113 (1961); Podlech in Prod. Südwestafrika 165: 23 (1967). *F. dichotoma* (L.) Vahl in Enum. Pl. **2**: 287 (1806) pro parte; Nees in Linnaea **9**: 290 (1834) name only; Kunth in Enum. Pl. **2**: 225 (1837) pro parte; A. Rich. in Tent. Fl. Abyss. **2**: 504 (1839–43); Boeck. in Peters Reise n. Mossam. **2**: 544 (1862–4) and in Linnaea **37**: 12 (1871) pro parte; Clarke in Hook. Fl. Brit. Ind. **6**: 635 (1893) and in Dur. & Schinz, Consp. Fl. Afr. **5**: 602 (1895); K. Schum. in Engl. Pfl. Ost. Afr.: 124 (1895); Dur. & Schinz in Etudes Fl. Congo **1**: 300 (1896); Clarke in Dyer Fl. Cap. **7**: 200 (1898), in Dyer Fl. Trop. Afr. **8**: 417 (1902) and in Bull. Misc. Inf., Addit. Ser. **8**: 107 (1908) name only; de Wild. in Pl. Bequaert. **4**: 204 (1927); Cherm. in Cat. Pl. de Madag. Mem. Acad. Malgache: 31 (1931); Brain in Proc. Rhod. Sc. Assoc. **33**: 85 (1934); Peter in Fedde Rep. **40**: 402 (1936–7); Cherm. in Fl. de Madag. (Cyperacees): 177 (1937).

*Scirpus umbellatus* Forsk. in Fl. Aeg.-Arab. **1**: 15 (1775).

*Annual*, erect, up to 46 (usually 10–26) cm in height, generally densely

tufted: *rhizome* visible only when shoots broken apart, up to 2 mm wide: *leaf sheaths* flattened to terete, entire when young, soon splitting from mouth to spread from shoot; densely white velutinous to pilose except at extreme base, keel flat to slightly rounded, occasionally projecting, membranous portion faintly many nerved, mouth sloping, inconspicuously white ciliate; *ligule* 0; *blades* always developed, up to 15, (generally 3—7) cm long, 1.0—2.8 mm broad, falcate, occasionally straight, glabrous to glabrescent adaxially sometimes becoming pilose towards sheath mouth, but hairs not aggregated to form a ligule, glabrescent to pilose abaxially, apex obtuse to acute: *flowering stems* generally slightly flattened, glabrous: *inflorescence* up to 7.2 cm long, up to 6.5 cm wide, a dense compound “umbel” of  $\pm$  175 spikelets, occasionally laxer due to reduction to 30—40; *pedicels* up to 4 cm. long; *bracts* 2—4, usually 3 well developed, equalling, slightly exceeding or shorter than inflorescence, sheaths with keel glabrescent, membranous portion white velutinous, blades leaf-like, glabrescent: *spikelets* 3—11 mm long, 1.2—1.6 mm broad, compact, polygonal, markedly angled by projecting glume keels, elliptic, lanceolate or oblong when young, lanceolate-oblong, occasionally elliptic in age, light to

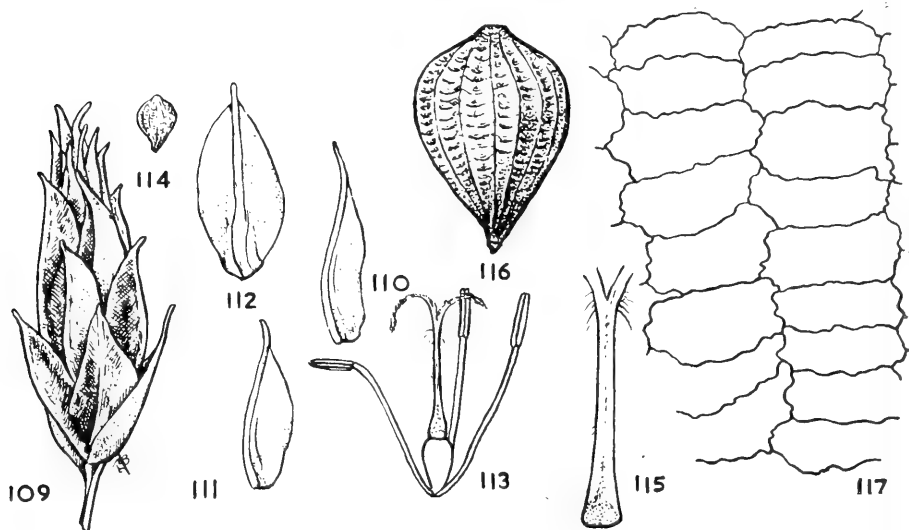


FIG. 9. *Fimbristylis bisumbellata* (Forsk.) Bub. (Codd 5722).

109—spikelet; 110–114—two lowest glumes of spikelet; 112—fifth glume from spikelet base; 113—young floret; 114—achene (all  $\times 7$ ); 115—style base and style ( $\times 14$ ); 116—achene ( $\times 28$ ); 117—epidermal pericarp cells ( $\times 196$ ).

golden brown with conspicuous green to cream nerves: *rachilla* nude: *glumes* delicate, lowest 1—2 sterile, bract-like, remainder fertile, 1.5—2.0 mm long, 0.95—1.3 mm in total width, ovate-oblong, pallid to golden yellow with delicate, narrow membranous margin, glabrous, keel markedly projecting, green to pallid, of 3 veins excurrent into well marked mucro, apex rounded, mucronate: *stamens* generally 1, occasionally 2 or 3 (all possibilities may occur within a spikelet); *anthers* 0.4—0.6 mm long, yellow to pale brown, apex rounded, obscurely crested: *style* 0.9—1.3 mm long including style base, approximately 0.08 (never attaining 0.1) mm wide, thread-like, slightly flattened in plane of achene, margins villous in upper half, style base deltoid, branches 2: *achene* 0.65—0.8 mm long, 0.4—0.6 mm wide, obovate, pale yellow to silvery white, surface with 5—8 prominent longitudinal ridges, trabeculate. Otherwise as *F. dichotoma* including outermost cells to pericarp.

*Flowering period.* Known to extend from August to January inclusive.

TYPE: Forskal s.n. (BM). "In locis litoreis in undatis insularum Niloticarum."

#### SELECTED CITATIONS

KENYA. Bura. Tana river, *Thain* 28 (PRE).

TANZANIA. Morogoro distr: Bwakira ya-ju, *Haarer* 1845 (EA); Rufiji distr: without precise locality, *Musk* 15 (EA); Usaramo distr: Usambara, banks of Pangani river, Mauri, *Greenway* 4020 (EA); distr. unknown: am Tigifluss bei Languza, *Peter* 8249 (EA).

ZAMBIA. Batoka distr: Livingstone, n. bank of Zambesi river, *Rogers* 13001 (BOL, GRA); Victoria Falls, Palm Island, *Wild* 3118 pro parte (SRGH); Mapanza, *Robinson* 354 (EARO).

MALAWI. Chickwawa distr: *Brass* 17936 (PRE).

MOZAMBIQUE. Macondes distr: near Rovuma river, *Pedro & Pedrogao* 5332 (LMJ, NU); Boruma distr: margins of Luenha river at confluence with Cuaredsi river, *Pedro & Pedrogao* 8188 (LMJ); Chimoio distr: Picada do Inchope at junction of Revue and Muda rivers, *Gomes Pedro* 4532 (PRE); Sabie distr: Ressano Garcia, *Schlechter* 11884 (BOL, GRA).

RHODESIA. Lomagundi distr: Urungwe, junction Sanyati and Fulechi rivers, *Phipps* 743 (PRE); Mtoko distr: Mkota Reserve, Mazoe river, *Wild* 2694 (SRGH); Hartley distr: Renje, Umniati river, *Whellan* 101 (SRGH); Bubi distr: Gwampa Forest Reserve, Bubi river, *Goldsmith* 24/56 (NU); Umtali distr: *Drummond* 4865 (PRE); Ndanga distr: Lundi river, Chiquanda Pools area, *Goodier* 617 (PRE).

SOUTH WEST AFRICA. Kunene river, *Story* 5834 (PRE); Namaqualand, banks of Orange river near Abbasas, *Pearson* 2996 (BOL); Great Namaqualand, Ai Ais, banks of Great Fish river, *Thorne* s.n. (NBG).

TRANSVAAL. Zoutpansberg distr: junction Pafuri and Limpopo rivers, Codd & Dyer 4633 (PRE); Nelspruit distr: Sand river, 3 miles e. of Skukuza Codd 5722 (PRE).

NATAL. Ingwavuma distr: Ndumu Game Reserve, Ward 3152 (NPGF, NU); do. Tinley 529 (NPGF, NU); 840 (NU).

In Africa the species is also known to occur in West Tropical Africa (Hutchinson, 1936), but no specimens from this region have been seen.

#### WORLD DISTRIBUTION

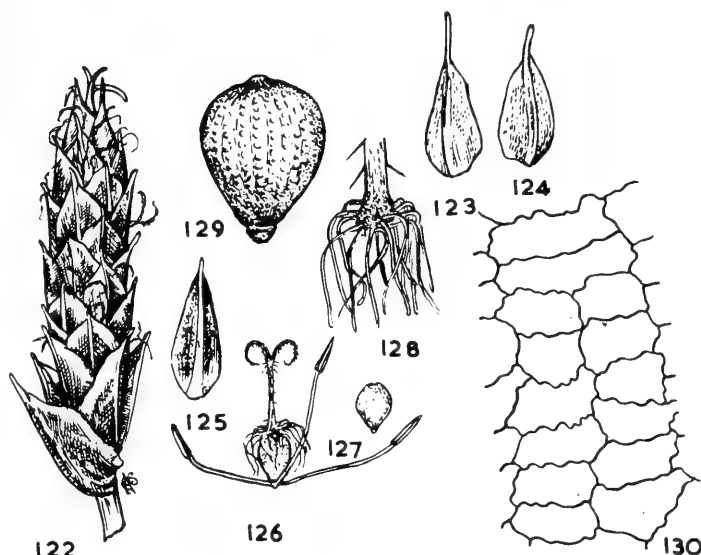
MALAGASY. Without precise locality, Decary 8299 (PRE). The species is also known from Reunion, India, Malaysia, Japan, Phillipine Islands, Australia and Southern Europe.

This tropical species is usually described as a weed. In Africa, south of the Zambesi river, *F. bisumbellata* has spread wherever the climate is tropical rather than temperate. It usually grows in sand, sand-clay or loam-clay soils, on banks and islands of rivers, or fringes of pans and hot springs. Zeyher 1779 is cited by Clarke (1898) as a mixed gathering, in part *F. squarrosa*, in part *F. bisumbellata* [= *F. dichotoma*]. The sheets of this number (K, PRE, NBG) seen during the present study have consisted entirely of the former species. If Clarke's citation of part of the gathering as *F. bisumbellata* is correct, then particular interest attaches to it, for the locality, "on the right side of the Olifants river from Vredendal to the mouth of the river", is southernmost in Africa: nor has the plant been recollected from there since 1830.

**5. *Fimbristylis squarrosa*** Vahl in Enum. 2: 289 (1806); Roem. & Schult. in System. Veget. 2: 96 (1817); Kunth in Enum. Pl. 2: 224 (1837); Steud. Syn. Pl., Glum. 2: 110 (1855); Boeck. in Linnaea 37: 10 (1871); Ridl. in Trans. Linn. Soc., Ser. II, Bot. 2: 149 (1884); Clarke in Hook. Fl. Brit. Ind. 6: 635 (1893) and in Dur. & Schinz, Consp. Fl. Afr. 5: 609 (1895); Dur. & Schinz in Etudes Fl. Congo 1: 303 (1896); Clarke in Dyer Fl. Cap. 7: 200 (1898); Rendle in Cat. Afr. Pl. Welw. II (1): 122 (1899); Clarke in Dyer Fl. Trop. Afr. 8: 413 (1902), in Bull. Misc. Inf. Addit. Ser. 8: 107 (1908) name only and in Illustr. Cyp. t. 41 f. 9-10 (1909); de Wild. in Pl. Bequaert. 4: 207 (1927); Cherm. in Cat. Pl. de Madag. Mem. Acad. Malgache: 33 (1931); Hutch. in Fl. W. Trop. Afr. II (2): 474 (1936); Cherm. in Fl. de Madag. (Cyperaceae): 176 (1937); Kern in Blumea 8, (1): 143 (1955); et in Reinwardtia 6, i: 48 (1961); Raymond in Dansk. Botanisk. Arkiv. 23, 3: 339 (1966); Podlech in Prod. Südwestafrika 165: 24 (1967). *F. ecklonii* Nees in Linnaea 9: 290 (1834) name only and in Linnaea 10: 145 (1835); Kunth in Enum. Pl. 2: 226 (1837).

*Pogonostylis squarrosa* (Vahl) Bertol. in Fl. Ital. 1: 312 (1833).

*Annual*, erect, up to 33 cm in height, generally densely tufted: *rhizome* visible only when shoots broken apart, 2-3 mm wide: *leaf sheaths* terete, entire

FIG. 10. *Fimbristylis squarrosa* Vahl (Bayer 1503).

122—spikelet; 123—4—two lowest glumes of spikelet; 125—fifth glume from spikelet base; 126—young floret; 127—achene (all  $\times 7$ ); 128—style base ( $\times 14$ ); 129—achene ( $\times 28$ ); 130—epidermal pericarp cells ( $\times 196$ ).

when young soon splitting apically to spread from shoot, white velutinous to pilose, keel rounded, slightly projecting, membranous portion faintly many nerved, mouth sloping, occasionally almost truncate, inconspicuously white ciliate; *ligule* 0; *blades* up to 18 cm long, 0.5—1.2 mm broad, erect, occasionally almost flexuous, glabrous to pilose adaxially, pilose to velutinous abaxially, apex acute: *flowering stems* glabrous: *inflorescence* up to 6.5 cm long, up to 6.0 cm wide, a more or less dense compound “umbel” of  $\pm 53$  spikelets; pedicels up to 35 mm long; *bracts* 3—4, usually 3 well-developed, equalling, slightly exceeding or shorter than inflorescence, leaf-like: *spikelets* 5—13 mm long, 1.0—2.0 mm broad, otherwise as *F. bisumbellata*; *rachilla* minutely winged: *glumes* delicate, lowest only sterile, bract-like, remainder fertile 1.9—2.2 mm long (including acumen), 0.8—1.3 mm in total width, ovate-oblong to oblong, golden yellow to pallid at base and at delicate, membranous margin, upper glabrous, lower pilose to glabrescent, keel as for *F. bisumbellata*, but mucron better developed, 0.2—0.7 mm long; *stamen* 1 only; *anther* 0.4—0.6 mm long, pale brown, crest darker: *style* 0.7—1.2 mm long including style

base, 0.14 mm wide, 1-nerved, slightly flattened in plane of achene, margins long villous in upper half, hairs pendulous, style base deltoid, margins white villous hairs forming a dense fringe across achene face, falling with style, branches 2: *achene* 0.6–0.8 mm long, 0.3–0.55 mm wide, obovate, pale yellow, surface often appearing smooth, but faintly reticulate or longitudinally striate and trabeculate: *outermost cells to pericarp* subquadrate to transversely elongate, scattered, occasionally in longitudinal series.

*Flowering period.* Known to extend from October to January inclusive.

TYPE: Herbarium Vahlia (C) probably collected by Loeffling in S. America (Ortega).

### SELECTED CITATIONS

TANZANIA. Rufiji distr: without precise locality, *Musk* 14 (EA).

ZAMBIA. Mongu distr: Zambesi river, Sandula Pontoon, *Drummond & Cookson* 6369 (SRGH, NU); Batoka distr: Livingstone n.w., *Robinson* 1449 (EARO).

MOZAMBIQUE. Manica-Sofala distr: Gorongosa Game Reserve, banks of Urema river, *Chase* 6982 (PRE); margins of Macaranga lagoon, *Pedro & Pedrogao* 8973 (LMJ).

RHODESIA. Mazoe distr: Henderson Research Station, conservation dam, *Crass* s.n. (NU); Bulawayo distr: Hillside dam, *Miller* 3681, 3252, 4793 (PRE); 7082 (SRGH, NU).

SOUTH WEST AFRICA. Ovamboland, Banks of Kunene river near Ruacana Falls, *de Winter* 3659 (PRE).

BOTSWANA. Ngamiland, without precise locality, *Curson* 827 (PRE).

TRANSVAAL. Zoutpansberg distr: towards Lake Fundusi, *Hutchinson* 2197 (PRE).

NATAL. Lower Umfolozi distr: Richard's Bay, *Bayer* 1503, 1505 (NU).

CAPE PROVINCE. Clanwilliam distr: Doorn River, *Drège* s.n. (K); van Rhynsdorp distr: Ebenezer, near Olifants river, *Drège* s.n. (K, NBG); in humidis ad Olifants river, *Ecklon & Zeyher* 73 (GRA); on the right side of Olifants river from Vredendal to the mouth, *Zeyher* 1779 (K, PRE, NBG).

The above description and citations refer to var. *squarrosa*, which is also reported for West Tropical Africa (*Hutchinson*, 1936), Angola (*Ridley*, 1884), the Congo (*Dur. & Schinz*, 1896) and N. Africa (*Koyama*, 1961), but no specimens from these regions have been seen.

### WORLD DISTRIBUTION

MALAGASY. Environs da Tananarive, *Bosser* 14935 (PRE); do. *Decary* 6854 (PRE). var. *squarrosa* is also known from S. Europe, India, Korea, Japan, China, N. Indo-China and S. America.

A second variety, *esquarrosa* Makino, with shorter mucronate glume apices is recognized. Kern, 1961, and Raymond, 1966, record it from Tropical Africa, but the few Tropical African specimens I have seen have all belonged to the typical variety.

Kern (1955) commented on the intimate relationship between *F. squarrosa* and *F. aestivalis* (Retz.) Vahl (which two species F. von Mueller (1875) united) and emphasized that their only reliable point of difference was the presence of long trichomes to the style base in the former that are absent or very short in the latter. Koyama (March, 1961) followed von Mueller and recognized *F. squarrosa* at varietal status only. Kern (Sept., 1961), despite his previous statement, again recognized both species and again commented on their close affinity. Raymond (1966) followed Kern without reference to Koyama's arrangement.

Worthy of further consideration in this connection is the following: Clarke 1895, 1898 cited *Cyperus hirtus* Thunb. in Phytogr. Blaett 1: 6 (1803) and in Fl. Cap. 1: 378 (1811) as a synonym under *Fimbristylis exilis* (Willd.) R. & S. Investigation in Thunberg's Herbarium (Bot. Mus. Univ. of Uppsala) showed the only sheet named *C. hirtus* (in Thunberg's hand) carries three specimens 35–50 mm in height that are in good agreement with Southern African specimens of *F. squarrosa* except that spikelets and floral parts are smaller and the hairs to the lower edge of the style base merely form a short fringe and do not overhang the upper half of the achene. On the reverse of the sheet, also in Thunberg's hand, is the note "e Cap. b. Spei, Osbeck". Thus Thunberg did not collect the plants himself, but obtained them from P. Osbeck, later Dean, who travelled to China in a Swedish ship as sea-chaplain in the years 1750–1752. In his "Journal of a Voyage", Osbeck does not mention going ashore along the southern African coast, but does mention visiting Ascension. The locality of his material is thus possibly this island.<sup>1</sup> These specimens are probably *F.*

I am indebted to C. G. Alm, Institute of Systematic Botany, University of Uppsala, for the information concerning Osbeck and for arranging the loan of Thunberg's specimen.

*squarrosa* var. *esquarrosa*, or they may be better placed with *F. aestivalis*. Without study of a range of material of both variety and species such a decision is difficult, especially as it has consequences. If Osbeck's plants are considered as var. *esquarrosa*, *C. hirtus* Thunb. antedates *F. squarrosa* Vahl, the valid name for which should then become *F. hirta*, provided Hooker, Bonpland and Kunth's type of *Isolepis hirta* (Nov. Gen. et Sp. 1: 224 (1813)) is *F. squarrosa* which synonymy and specimens from the same approximate locality suggest. Of course, if Osbeck's plants are placed with *F. aestivalis*, or if this species is definitely conspecific with *F. squarrosa*, then *F. aestivalis* remains the oldest, valid name for the taxon.

Since I have not examined Retzius' type of *Scirpus aestivalis*, and since I am insufficiently familiar with this species over its range of distribution, I prefer to retain the Southern African plants under *F. squarrosa* var. *squarrosa*, pending further study.

In Southern Africa this variety is always to be found near water, either favouring the same habitats as *F. bisumbellata* (a number of mixed gatherings are on record), or in the sandy, saline soils of lagoons and coastal mudflats, where it is one of the earliest colonizers.

6. *Fimbristylis ferruginea* (L.) Vahl in Enum. Pl. 2: 291 (1806); Kunth in Enum. Pl. 2: 236 (1837); Boeck. in Peters Reise n. Mossam. 2: 544 (1862-64) and in Linnaea 37: 16 (1871); Bak. in Fl. Maur. 419 (1877); Ridl. in Trans.

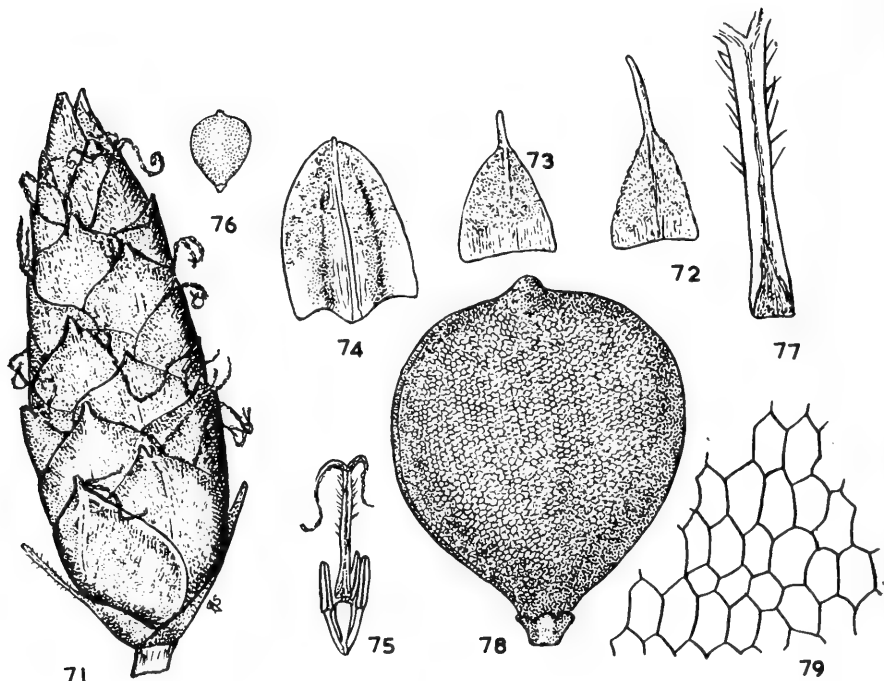


FIG. 11. *Fimbristylis ferruginea* (L.) Vahl (Ward 2125).

71—spikelet; 72-3—two lowest glumes of spikelet; 74—fifth glume from spikelet base; 75—young floret; 76—achene (all  $\times 7$ ); 77—style base and style ( $\times 14$ ); 78—achene ( $\times 28$ ); 79—epidermal pericarp cells ( $\times 196$ ).



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*Scirpus ferrugineus* Linn. in Sp. Pl. ed. 1: 50 (1753) and in Sp. Pl. ed. 2: 74 (1762).

*Biennial*, sometimes annual or perennial, erect, up to 80 cm in height, sparsely to densely tufted, sterile shoots infrequent in mature plants: *rhizome* visible only when shoots broken apart, seldom exceeding 3 mm in width, persistent tunic of leaf bases usually lacking: *leaf sheaths* and *ligule* as in *F. dichotoma* except for the less well developed indumentum and more markedly projecting keel, so that in *F. ferruginea* sheaths are often glabrescent to pilose on membranous portion in upper half only, occasionally glabrous throughout; *blades* always developed, up to 31 cm long,  $1.2-2.3$  ( $1.78 \pm 0.065$ ) mm wide, linear, herbaceous, glabrous, almost glaucous in life, margins thickened to ridged, generally slightly involute, closely scabrid pubescent to smooth, apex broadly acute, often asymmetric, scabrid: *flowering stems* usually glabrous throughout, otherwise as in *F. dichotoma*: *inflorescence* up to 7.3 cm long, up to 3.4 cm wide, a compound or simple "umbel" of 16–4 spikelets, occasionally markedly reduced to a single head of sub-sessile spikelets; *pedicels* up to 3.5 cm long, glabrous; *bracts* 2–4, usually much exceeding, occasionally equalling or shorter than inflorescence, sheaths white pubescent, blade glabrous: *spikelets* 6–17 ( $12.25 \pm 0.75$ ) mm long,  $3.0-5.0$  ( $3.83 \pm 0.10$ ) mm broad, compact, cylindric, scarcely angled by glume keels, elliptic when young, oblong to lanceolate-ovate in age, obtuse to acute, ferruginous brown overlaid light grey, basal

glumes early deciduous; *rachilla* straight, deeply notched, showing spiral arrangement of glumes, shortly winged except at extreme base, wings acute to acuminate, ferruginous brown; *glumes* lowest 1–2 sterile, bract-like, remainder fertile, 3.2–4.9 ( $4.0 \pm 0.09$ ) mm long, 2.7–4.9 ( $3.72 \pm 0.15$ ) mm in total width, broadly ovate to orbicular, glabrous adaxially, grey velutinous in upper half abaxially, keel hardly projecting, of one green to brown vein excurrent into mucron, apex rounded, mucronate: *stamens* 3; *anthers* 1.08–1.6 ( $1.28 \pm 0.08$ ) mm long, yellow to brown, crest minute, smooth, reddish-brown, base minutely auricled: *style* 2.8–3.2 mm long including style base, 0.27–0.52 ( $0.37 \pm 0.01$ ) mm wide at narrowest point, ribbon-like, flattened in plane of achene, 1–3 nerved, margins long villous in upper two-thirds, glabrous below, style base generally not, occasionally very slightly exceeding style width, branches 2, as in *F. dichotoma*; *achene* 1.25–1.7 ( $1.48 \pm 0.04$ ) mm long, 0.7–1.3 ( $1.05 \pm 0.04$ ) mm broad, biconvex, obovate to almost orbicular, yellow, apex minutely projecting, surface faintly reticulate, gynophore developed; *outermost cells to pericarp* subquadrate (hexagonal), eventually velate.

Flowering period: October to May inclusive.

TYPE: Deposited in Linnean Herbarium, London. Linnaeus (1753) gave the type locality as, “in Jamaica paludibus maritimis”, but it is not known with certainty whether this applies to the specimen recognized as the type.

## SELECTED CITATIONS

MAURITANIA. Sahara desert. Terjit (Adrar) *Naegele* 114 (PRE).

SOMALIA. Between Halin and Bihen, *Glover & Gilliland* 132 (EA).

TANZANIA. Usaramo distr: Dar-es-salaam, *Holst* 4193 (EA); Zanzibar, Chukwani, *Tait* 23 (NU).

ZAMBIA. Batoka distr: Mapanza n.w. *Robinson* 935 (EARO); East Loangwa distr: Msoro, 50 ml. w. of Fort Jameson, *Robinson* 848 (EARO).

MOZAMBIQUE. Portobelo distr: Quelimane, *Sim* 20746 (NU); Buzi distr: picada do Lonchope as R. Buzi, entre R. Revue e.o. R. Buzi, R. Rucuro, *Gomes Pedro* 4539 (PRE); Sul do Save, vale do Limpopo. *Myre* 1286 (LM, NU); Inhaca Island, Lighthouse fringe of n. shore, *Mogg* 26930 (PRE); sandveld near saltmarsh, *Mogg* 16703 (PRE).

RHODESIA. Darwin distr: Kendeya Nature Reserve, *Phipps* 2318 (SRGH, PRE); Binga distr: Chikwata Hot Springs, *Phipps* 1590 (PRE); Mazoe distr: Bindura, *Brain* 8028 (BUL, LMJ); Buhera distr: Sabi Valley, Honde dip, Whellan 254 (SRGH); Chipinga distr: e. Sabi, Upper Rupembe, *Phipps* 81 (PRE); Ndanga distr: Chipinda Pools area, *Goodier* 617 (SRGH, PRE); Gwanda distr: near Similala river, about 9 ml. w. of Fort Tuli on old road to Maklantsi, Tusi Circle, *Drummond* 6132 (SRGH, NU).

SOUTH WEST AFRICA. Okahandja distr: farm, "Gros Barmen", *Merxmüller & Giess* 1016 (PRE, M); prope Barmen, *Marloth* 1364 (PRE, GRA).

TRANSVAAL. Sibasa distr: Malathlapanga, near Sibasa, *van der Schyff* 5664, 5659 (PRE); Lydenburg distr: farm "Ironstone", *Barnard & Mogg* 822 (PRE, NU); Pretoria distr: near Wonderboom Poort, banks of Aapias River, *Labuschagne* s.n. (PRE); Pienaar's River, *Rehmann* s.n. (K); Bon Accord, 9 ml. n. of Pretoria, *Mogg* 12399 (PRE); Barberton distr: Rose's Creek, *Thorncroft* B2 (PRE).

SWAZILAND. Manzini distr: Bulunga Poort, *Compton* 31840 (SGH, PRE).

ORANGE FREE STATE. Without precise locality, *Buchanan* 145 (K).

NATAL. Utrecht distr: streamlet near Kingsley, *Gordon-Gray* 4995 (NU); Vryheid distr: near Vryheid, *Gordon-Gray* 4990 (NU); Ngotshe distr: Ngotshe bank of Nkuzana River between Nongoma and Magudu, *Gordon-Gray* 4762 (NU); Dundee distr: Dundee near Waschbank River, *McClellan* 88 (SRGH, PRE); Hlabisa distr: Hluhluwe Game Reserve, *Ward* 2125 (NU, NPGF); St. Lucia Estuary, Narrows, *Ward* 4371 (NU, IU); Klip River distr: Grobbelaar's Kloof near Colenso, Onderbroekspruit, *Acocks* 10012 (NH, PRE); Lower Umfolozi distr: Richard's Bay, *Bayer* 1507 (NU); Weenen distr: Weenen, Sun Valley Estates, *Basel* 61 (NU); Lower Tugela distr: Tugela Mouth, *Edwards* 1726 (PRE, NU); Inanda distr: Mount Edgecombe, *McMartin* 13 (NH, PRE); Durban distr: Durban Flat, *Buchanan* 55 (K, PRE); Port Shepstone distr: Port Edward, along beach towards Munster, *Huntley* 754 (NU).

CAPE PROVINCE. Lusikisiki distr: near mouth Umsikaba River, *Drège* s.n. (K); Port St. John's distr: Port St. John's, *Moss* 5509 (J); Elliotdale distr: The Haven, *Gordon-Gray* 404 (NU); Komgha distr: Kei Mouth, *Schlechter* 6192 (GRA, NBG); King William's Town distr: Pirie, *Sim* 917 (NU); East London distr: East London, *Ratray* 727 (GRA); Bathurst distr: near Fish River mouth, *Dyer* 3387 (PRE).

In Africa the species is also reported for Angola (*Rendle*, 1899) and West Tropical Africa (*Hutchinson*, 1936), but no specimens from these localities have been seen.

#### WORLD DISTRIBUTION

MALAGASY. Vavatohe, *Hildebrandt* 3321 (K); Antanimora, *Decary* 3810 (PRE).

The species is also known from Mauritius, India, Australia, the Lesser Sunda Islands (Timor), the Phillipine Islands (Mindanao) (*F. sieberana*) Malaysia and Tropical America (*F. ferruginea*).

Kern (1955) upheld Kunth (1837) in segregating from *F. ferruginea*, the closely allied *F. sieberana* mainly on the basis of differences originally expressed by Kunth (Table 1). Kern regarded *F. sieberana* as "a well characterized

species", but this was not the opinion of workers who had dealt with the taxa in other parts of the world. Thus Clarke (1898) cited *F. sieberana* as a synonym of *F. ferruginea*, while Chermeson (1937) cited both *F. ferruginea* and its variety *sieberana* for Malagasy. According to Kunth, *F. sieberana* is to be found at the Cape of Good Hope (known distribution shows the species to extend no further south than the Great Fish River, however), but study of Southern African plants in field and herbarium, with particular attention being given to characters considered critical by Kern, has shown these plants to link this species with *F. ferruginea*. The description of *F. ferruginea* in the present paper shows that while the means and standard errors of the means tend towards Kern's parameters for *F. sieberana*, extremes show overlap with figures for *F. ferruginea*. In addition, individual plants frequently show certain features of Kern's *F. sieberana* associated with others of his *F. ferruginea*. Consequently both taxa could not be maintained, and Southern African plants are here named *F. ferruginea* with *F. sieberana* considered synonymous. I have not, however, examined Kunth's type in the Willdenow herbarium.

*F. ferruginea* is most easily diagnosed by the short, fine, grey adpressed pubescence on the abaxial surface in the distal half of the glume. Despite Clarke's (1898) comment, ". . . but the glumes are occasionally absolutely glabrous", no such specimens have been seen except that show other evidence of hybridization.

Brain (1934) described the "umbel" as, "lax with usually 30-40 large, ferruginous spikelets which are usually variegated with yellow". This number of spikelets is excessive for the species, since in all specimens studied from south of the Zambesi River, including many from Rhodesia, no more than 16 spikelets have been found. Use of the word, "lax", is also an over-statement.

*F. ferruginea* always favours damp situations in sand and mud along river banks and in vleis that tend partially to dry during the unfavourable season. Particularly is the species common at the coast; in marshy places near lagoons; in crevices among rocks where soil is kept moist by water from streamlets or seepages; or in low-lying grassveld periodically inundated. There is tolerance of saline conditions, for plants may occur so close to the sea that they are affected by salt spray throughout the year and occasionally by waves at spring tide. In estuaries plants are also often subjected to inflow of sea water. Occasionally plants grow along rivers and stream banks considerable distances from the sea (Tugela river near Colenso; Bushman's river valley near Estcourt; Barberton district, Transvaal), generally where soils contain a high percentage of sand. Brain (1934) refers to the species in Rhodesia as, "a tall tufted perennial of red soils, attaining its greatest development in semi-vlei conditions".

*F. ferruginea*, like most species of the genus, is a heliophyte and intolerant of intense shade.

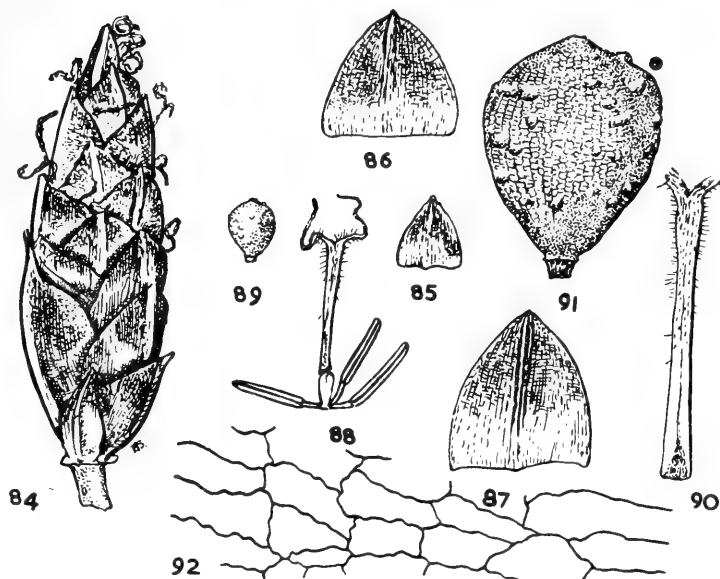


FIG. 12. *Fimbristylis longiculmis* Steud. (Boivin 1657).

84—spikelet with lowest glume removed; 85–86—two lowest glumes of spikelet; 87—fifth glume from spikelet base; 88—young floret; 89—achene (all  $\times 7$ ); 90—style base and style ( $\times 14$ ); 91—achene ( $\times 28$ ); 92—epidermal pericarp cells ( $\times 196$ ).

7. *Fimbristylis longiculmis* Steud. in Syn. Pl. Glum. 2: 110 (1855); Clarke in Dur. & Schinz, Consp. Fl. Afr. 5: 607 (1895); K. Schum. in Pfl. Ost. Afr.: 124 (1895); Clarke in Fl. Trop. Afr. 8: 417 (1902) and in Bull. Misc. Inf., Addit. Ser. 8: 108 (1908) name only; Cherm. in Cat. Pl. de Madag.: 32 (1931); Peter in Fedde Rep. 40: 401 (1936–7); Cherm. in Fl. de Madag. (Cyperacees): 180 (1937). *F. sanzibarensis* Boeck. in Flora: 437 (1880).

The following description is based on tropical as well as Southern African specimens since so few populations are known south of the Zambesi River:

*Perennial*, erect, up to 135 cm in height, tufted: *rhizome* woody, up to 7 mm wide of shoot bases confluent in a uniseriate row or an irregular tuft, clothed by hard, acute scale leaves: *leaf sheaths* entire only when young, soon splitting apically to spread slightly from shoot, flattened, glabrescent, many nerved, keel not prominent, mouth truncate, white ciliate; *ligule* a dense fringe of white hairs; *blades*, up to 21 mm long, up to 1 mm wide, stiff coriaceous, each the apiculate continuation of main nerves of sheath, white pilose to glabrescent adaxially, glabrous abaxially, margins thickened, slightly involute, apex broadly

obtuse: *flowering stems* erect, compressed and 2-angled in young state and immediately below inflorescence, spongy, sometimes faintly transversely striate when dry, glabrous: inflorescence up to 10 cm long, up to 6 cm wide, a compound "umbel" of  $\pm 30$  spikelets; *pedicels* up to 8 mm long, as flowering stems; *bracts* 2—4, up to 11 mm long, poorly developed, shorter than inflorescence, coriaceous: *spikelets* 13—15 mm long, 3·2—5·0 mm wide, compact, cylindric, scarcely angled by glume keels, lanceolate to lanceolate-ovate when young, oblong in age, brown, usually shining, with green to fawn markings, apex acute, basal glumes early deciduous; *rachilla* straight, deeply notched showing spiral arrangement of glumes, dark brown, nude: *glumes* lowest 1—3 sterile, reduced, remainder fertile, 3·4—4·4 mm long, 2·8—4·4 mm in total width, broadly ovate to elliptic oblong, golden brown, darker speckled, glabrous, occasionally sparsely grey pubescent abaxially in distal half, keel poorly defined, of 5—6 closely placed veins, apex obtuse, mucronate: *stamens* 3; anthers 1·4—2·1 mm long, brown, crest minute: *style* 2·8—3·5 mm long including style base, 0·2—0·27 mm wide at narrowest point, ribbon-like, 3-nerved, margins long villous especially in upper half, pale to mid-brown, style base slightly exceeding width of style, branches 2, as in *F. dichotoma*: *achene* 1·1—1·2 mm long, 0·9—1·1 mm broad, similar to that of *F. ferruginea* except that it is obovate rather than orbicular, often darker brown and with a poorly developed gynophore, surface variously marked, reticulate, or longitudinally ridged and faintly trabeculate, markedly to sparsely tuberculate especially near ridges, occasionally etuberculate; *outermost cells to pericarp* subquadrate (hexagonal to rectangular) wider than deep, irregular or placed in longitudinal series, eventually velate.

*Flowering period*: September to March inclusive.

TYPE: Boivin 1657, collected January, 1848, Sainte-Marie, Malagasy (Madagascar) P.

#### SELECTED CITATIONS

TANZANIA. Mafia Island, Kilindoni, *Fitzgerald* 5211/5 (EA); Usaramo distr: Dar-es-salaam, *Holst* 4128 (EA); bei Dar-es-salaam *Peter* 44817 (EA); Zanzibar, without precise locality, *Kirk* s.n. (K).

MOZAMBIQUE. Homoine distr: Zandemela near Inhambane, *Lawrence* 2 (NBG); near Inhambane, region of Cumbane, *Gomes E. Souza* 2233 (PRE).

NATAL. Hlabisa distr: St. Lucia, eastern shores, *Feely* and *Ward* 16 (NPGF, PRE, NU).

#### WORLD DISTRIBUTION

MALAGASY. Central Malagasy, *Baron* 1363 (K); Ambilo (s. de Tamatave) *Decary* 6419 (PRE); Ahimena, Ampahana, Antalaha (NE), *Kiener* s.n. (PRE); without locality, *Gerrard* s.n. (K).

Clarke (1902) referred to *F. longiculmis* “. . . as though a very large form of *F. ferruginea*. It differs in the glumes being glabrous on the back and in the larger, harder, darker coloured spikelets”. Relationship between the two species is certainly close, but all specimens of *F. longiculmis* seen have been taller and more robust than is usual for *F. ferruginea*. In addition the flowering stems are coarse and spongy with transverse septations that sometimes become faintly visible externally on drying. This character, together with the reduction of leaf blades and inflorescence bracts, suggests the species grows in water for considerably longer periods than does *F. ferruginea*. Clarke's comment on the spikelets being glabrous on the back generally applies to herbarium material filed under *F. longiculmis*. In how far this is due to the identification of pubescent-glumed specimens as robust examples of *F. ferruginea*, is worthy of consideration. Peter 39370 and 39325 from Dar-es-salaam, Tanzania (EA) need re-appraisal in this connection in conjunction with field study of populations in the same locality.

Steudel, in describing the species, could not have seen fully mature fruits, for he concluded, “achenio—?”. Clarke (1902) described the nuts, “. . . as for *F. ferruginea*”. There is, however, much greater variation in sculpturing of the pericarp wall in *F. longiculmis* than within *F. ferruginea*. In addition the achenes are frequently tuberculate, but examples varying from markedly tuberculate to etuberculate occur, often a wide range being represented on a single plant.

## HYBRIDS

The species considered in this paper are undoubtedly closely related. It is not surprising, therefore, that study of them in field and in herbarium has brought to light evidence of putative interspecific hybrids. In Natal and further south into the Transkei and the Cape Province, where, of the species under consideration, only *F. ferruginea* and *F. dichotoma* occupy a common distributional range, the putative hybrids show characters of both these species. Further north into Tropical Africa where *F. bisumbellata* is also widespread and occupies, in part at least, a common distributional area with the other already named taxa, putative hybrids between *F. bisumbellata* and *F. dichotoma* are also to be found. Clarke (1902), in dealing with Tropical African Cyperaceae, remarked, “*F. diphylla* (*F. dichotoma*) is so close to . . . *F. dichotoma* (*F. bisumbellata*) that different cyperologists sort the material, as between these two, differently.” Kern (1955) writing on Malaysian Cyperaceae, in which locality *F. bisumbellata* is extremely rare, stated, “Clarke, 1907, is of the opinion that *F. bisumbellata* is only distinguishable from *F. dichotoma* by characters of trifling importance. However, I always find the much smaller spikelets, the smaller, membranous, mucronate, sharply keeled glumes, the much shorter style, and the smaller nut sufficiently differentiating characters.” Ease of identification is dependent

upon the degree of morphological discontinuity among the taxonomic units under consideration. In the case of *F. dichotoma* and *F. bisumbellata* this discontinuity is sharply defined in the Malaysian and Southern African flora, but in Tropical Africa and India is blurred by the occurrence of many sporadic interspecific hybrids and possibly also hybrid swarms.

In Natal, where much field work has been carried out, no hybrid swarms between any two of the species under consideration have been encountered to date. The explanation for the occurrence of sporadic interspecific hybrids only, probably lies in the differing habitat requirements of the parental species, the intermediate habitats necessary for hybrids to succeed being generally poorly represented.

The sporadic hybrids are interesting, since besides exhibiting admixture of

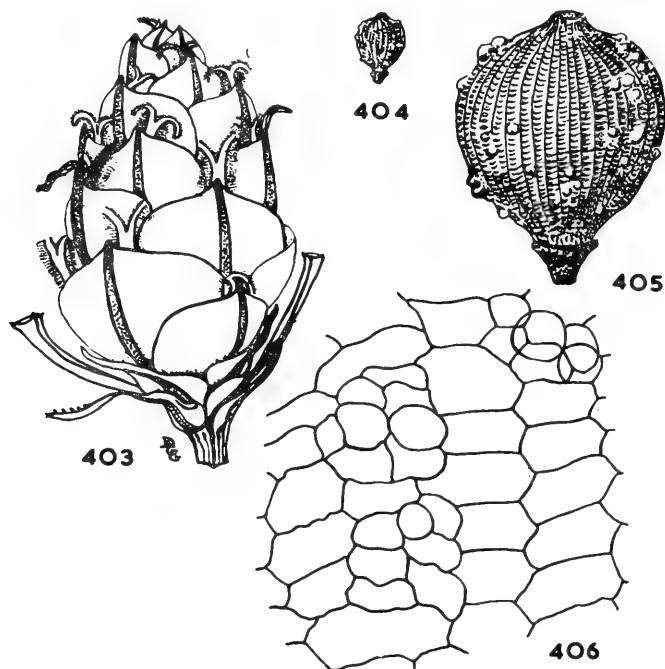


FIG. 13. *Fimbristylis*  $\times$  *dregeana* Kunth. (pro species) (Drège, between Umtentu and Umzimkulu Rivers, Cape Province).  
403—spikelet; 404—achene (both  $\times 7$ ); 405—achene ( $\times 28$ ); 406—epidermal pericarp cells ( $\times 196$ ).



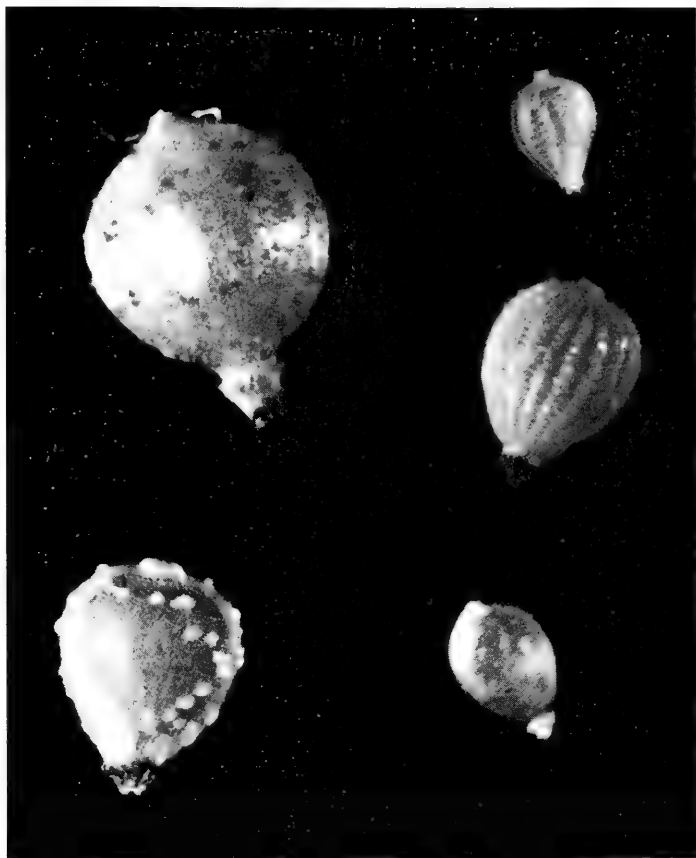


FIG. 14.

Mature achenes: top left—*F. ferruginea*; bottom left—*F. longiculmis* (both  $\times 30$ ); top right—*F. bisumbellata*; middle right—*F. dichotoma*; lower right—*F. squarrosa* (all  $\times 20$ ).

structural features of the putative parents, many of the achenes are tuberculate (etuberculate in the "pure" species). Such an example is the type of *F. dregeana* Kunth (Drège s.n., Pondoland, from between Umtentu and Umzimkulu rivers K. figs. 403–6) which carries tuberculate achenes of the approximate size of those of *F. ferruginea*, and with pericarp cells near the size for this species,

but of the shape of *F. dichotoma*. The spikelets are few and broad as in *F. ferruginea*, but with the glabrous glumes of *F. dichotoma*.

The association of tuberculation of the pericarp wall with hybridization needs confirmation from experimentation before it can be accepted, but repeated correlation of morphological evidence of interspecific hybridization with the development of tuberculate achenes is suggestive. Variation in the pericarp sculpturing and tuberculation of the achenes of *F. longiculmis* points to a possible hybrid ancestral origin for this species, *F. ferruginea* perhaps being one parent.

## DISCUSSION

Attention has already been drawn to the closeness of relationships among the species considered in this paper. Despite this, and despite the occurrence of interspecific hybrids, identification of plants from localities south of the Zambesi river should seldom be difficult, provided observations are not cursory, for characters are usually well marked.

Grouping of the species into sections or series is not so straightforward, however. Doubts arise as to whether the present segregation of *Dichelostylis* from the type section *Fimbristylis* (Kern, 1955) on the basis of sculpturing of the external surface of the pericarp, is not too "fine" a distinction, especially when *F. longiculmis* with its variable achene surface, is included. Would not the union of both sections under the type name *Fimbristylis*, be more natural? A decision must await further evidence from other fields of investigation.

*F. bisumbellata* has not always been placed with *F. dichotoma* within section *Fimbristylis*, (following Kern l.c.). Ohwi, 1938, placed it with *F. squarrosa*, while Koyama, 1961, referred to its intermediate nature thus, "The smaller spikelets with lighter coloured scales, smaller achenes with less fimbriate style, and slender culms and leaves suggest that this is near to *F. squarrosa* as Ohwi (l.c.) treated. The ligule of a fringe of pubescence, however, shows that this species is also related to the *F. dichotoma* group." Examination of African specimens of *F. bisumbellata*, (with the possible exception of plants showing other characters indicative of hybridization with *F. dichotoma*) shows clearly that a ligule is lacking. Hairs at the base are often more densely packed than those higher on the leaf blade, but they are never aggregated into a definite fringe that constitutes a ligule. A difference in the texture and thickness of tissue between sheath apex and blade base is detectable, but this also cannot be interpreted as a ligule. This finding supports Ohwi's arrangement and serves to emphasize the many structural features that *F. bisumbellata* and *F. squarrosa* possess in common. Both species also behave as weeds readily colonizing exposed areas with suitable habitat conditions. *F. bisumbellata* should thus be included with section *Pogonostylis* rather than with *Dichelostylis* as Kern advocated.

## KEY TO IDENTIFICATION

1. Faces of achenes covered in hairs pendant from style base: glumes long acuminate . . . . . 5. *F. squarrosa* var. *squarrosa*.  
 Faces of achenes naked, not covered in hairs pendant from style base: glumes rounded to mucronate, not long acuminate . . . . . 2.
2. Achene surface clearly longitudinally ridged and trabeculate: leaf blades developed . . . . . 3.  
 Achene surface reticulate, not clearly longitudinally ridged and trabeculate (if faintly longitudinally ridged and trabeculate, then leaf blades reduced to apiculi terminating the sheaths) . . . . . 4.
3. Spikelets 2—3 mm broad scarcely angled by projecting glume keels; rachilla ragged with wings of persistent tissue: style 0.15—0.28 mm wide at narrowest point . . . . . 3. *F. dichotoma*.  
 Spikelets 1.2—1.6 mm broad, markedly angled by projecting glume keels; rachilla naked, without wings of persistent tissue: style approximately 0.08 (never attaining 0.1) mm wide at narrowest point . . . . . 4. *F. bisumbellata*.
4. Glumes grey pubescent abaxially in distal half: achenes etuberculate, obovate to orbicular with clearly developed gynophore; achene surface reticulate (epidermal pericarp cells hexagonal): flowering stems not spongy and coarse, never with transverse septa visible . . . . . 6. *F. ferruginea*.  
 Glumes glabrous, or sparsely grey pubescent abaxially in distal half: achenes usually tuberculate, especially near ridges, occasionally etuberculate, obovate with poorly developed gynophore; achene surface reticulate or faintly longitudinally ridged and trabeculate (epidermal pericarp cells subquadrate (hexagonal to rectangular, broader than long): flowering stems spongy and coarse, sometimes with transverse septa visible . . . . . 7. *F. longiculmis*.

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TABLE I

Criteria used by Kern, 1955, to distinguish between *F. ferruginea* and *F. sieberana*.

<i>F. ferruginea</i>	<i>F. sieberana</i>
"Lower sheaths coriaceous, shining brown to castaneous, upper . . . ciliolate at the mouth, otherwise glabrous.	"Lower sheaths not coriaceous, stramineous to ferruginous, upper . . . pilose especially towards the top, sometimes glabrescent.
Blades of the cauline leaves rigid, short, 2—10 cm long, $\frac{1}{2}$ —1 $\frac{1}{2}$ mm wide.	Blades of the cauline leaves grasslike, up to 35 cm long, $1\frac{1}{2}$ —2 mm wide.

Involucral bracts usually shorter than the inflorescence.

Spikelets acute.

Glumes ovate to oblong,  $3-4\frac{1}{2} \times 2\frac{1}{2}-3$  mm, puberulous in the apical part, ferrugineous.

Style 0.25 mm wide.

Nut obovate to oblong—obovate, shortly stipitate,  $1-1\frac{1}{4} \times \frac{3}{4}-1$  mm."

Lowest involucral bract usually overtopping inflorescence, up to 10 cm long.

Spikelets obtuse.

Glumes very broadly ovate,  $3-4\frac{1}{2}$  mm long and wide, densely tomentose in the apical part, usually castaneous.

Style about 0.4 mm wide.

Nut broadly obovate to orbicular, distinctly stipitate,  $1\frac{1}{4}-1\frac{1}{2} \times 1\frac{1}{10}-1\frac{1}{4}$  mm."

# THE EFFECT OF TRACE ELEMENT DEFICIENCIES ON THE BOTRIVER PROTEA (*PROTEA COMPACTA*, R. BR.) IN WATER CULTURE†

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## ABSTRACT

The effects were investigated of deficiencies of the trace elements boron, manganese, copper, molybdenum, and zinc on the growth of *Protea compacta* grown in water culture. Foliar deficiency symptoms developed for all elements but only deficiencies in the rooting medium of boron, copper and manganese had appreciable effects on amplifying growth.

## INTRODUCTION

There have as yet, been few attempts to study the nutritional requirements of the members of the South African Proteaceae. Though some observations on *Protea cynaroides* have been published (van Staden, 1967, 1968) our knowledge is still very inadequate. Deficiency symptoms have seldom been recorded in plants growing in the wild and the only indication that the natural plant community in the Western Cape may suffer from malnutrition was reported by Schütte in 1960. The object of the present study was to assess the role of the trace elements boron, manganese, molybdenum, copper and zinc on the growth of one member of the Proteaceae.

## MATERIAL AND METHODS

Fresh seeds of *P. compacta* R. Br. (obtained from the South African Forestry Department, Cape Town) were germinated in moist sand in the laboratory, and the seedlings transferred to 1.2 L glass containers before the first leaf appeared. They were grown on in a greenhouse between 12° and 39°C and were aerated for one hour every day. The cultures were arranged in a randomised block design with six replicates of each treatment.

There were six treatments, viz. complete mineral nutrients and solutions minus the trace elements boron, copper, manganese, molybdenum and zinc.

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The basic solution consisted of Hoagland and Arnon's (1950) No. 2 nutrient solution in de-ionised water. The micronutrient supplement contained 18 mg NaFe-EDTA, 1.0 mg B (as  $\text{H}_3\text{BO}_3$ ), 1.0 mg Mn (as  $\text{MnSO}_4$ ), 0.04 mg Cu (as  $\text{CuSO}_4$ ), 0.1 mg Zn (as  $\text{ZnSO}_4$ ), and 0.02 mg Mo (as  $\text{H}_2\text{MoO}_4 \cdot \text{H}_2\text{O}$ ), per litre of solution. The containers were refilled with fresh nutrient solution every two weeks. In addition the level of the solution was kept constant by the frequent addition of de-ionised water.

The plants were harvested eight weeks after transferring the seedlings to the containers, and the total length of the stem, number of leaves, shoot dry weight and root dry weight were then recorded.

### RESULTS AND DISCUSSION

The development of deficiency symptoms and the descriptions of these symptoms for each element tested are given in Table 1. The symptoms in all cases appeared more or less at the same time, approximately one month after transplanting. A typical plant, grown in the absence of copper, is illustrated in Plate 1.

TABLE 1  
The development of symptoms of trace element deficiencies in *Protea compacta*

Treatment	No. of days from transplanting	Symptoms
—B	34	Leaves slightly distorted and curled, the intervenal areas tinted purple. Older leaves dying from the tips.
—Cu	34	Young leaves failed to unroll. Old leaves became slightly chlorotic and severely wilted, followed by necrosis.
—Zn	35	Leaves chlorotic at intervenal areas as well as malformed.
—Mo	42	Leaf tips became necrotic.
—Mn	43	Purple spots appeared on leaves in a mottled pattern. In some cases the leaf tips died.
		Leaf tips became chlorotic and necrotic areas appeared next to the main veins.

The effects of deficiencies of the various nutrients on plant yield are given in Table 2. Deficiencies of molybdenum and zinc had no significant effect on any of the growth characteristics measured. Manganese deficiency resulted in a significant decrease in shoot weight and root weight, but not in stem length or the number of leaves. Deficiency of the other two elements, boron and copper, had significant effects on all of the characteristics measured. It is of interest that these results are in accordance with the findings of Moore and Keraitis (1966) on *Grevillea*. They found that "absence of copper, molybdenum,

or zinc had no measurable effect on growth of the seedlings. Boron deficiency caused a significant reduction in height and leaf weight, and manganese deficiency significant reductions in height, stem diameter, stem weight, leaf weight, and root weight." The present results are also similar to those previously reported in a variety of other plants (Wallace, 1961.)

TABLE 2  
Effect of trace element deficiencies on the growth of *P. compacta*

	Treatment						L.S.D.
	Control	—B	—Cu	—Mn	—Mo	—Zn	P = 0.05
Number of leaves . . . .	25.8	19.8	10.7	21.1	22.0	21.0	4.57
Stem length (cm). . . .	9.81	6.13	6.21	7.21	7.18	9.23	3.07
Dry weight of shoots (mg) .	194	132	131	123	165	174	61
Dry weight of roots (mg). .	62	45	42	39	62	60	5

It is also of further interest that, as was found to be the case with the major nutrient elements (van Staden, 1968), this species is very sensitive to variation in the trace element supply. As can be seen from Table 1 all the treatments brought about signs of malnutrition between 34–42 days after commencing the treatments. This is in spite of the presence of large cotyledons, which might provide a temporary source of trace elements. After four months of growth in the absence of trace elements, *Grevillea robusta* (Moore and Keraitis, 1966) showed deficiency symptoms only on plants not receiving boron and manganese, while the other plants were normal.

One of the purposes of the experimental work described above was to record the symptoms of trace element deficiencies as developed in *P. compacta*. This information may contribute to the recognition of deficiency symptoms in plants in the field. However, the data reported here was obtained from very young plants and may not be directly applicable to mature plants, although in view of the findings of Schütte (1960), such an extension appears to be justified.

#### ACKNOWLEDGEMENTS

I wish to thank Dr. A. R. A. Noel for his assistance with the preparation of the manuscript.

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# A PLANT ECOLOGICAL RECONNAISSANCE OF THE UPPER MGENI CATCHMENT†

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## INTRODUCTION

The following account is a summary of a plant ecological study undertaken in 1964. The full report was submitted as a thesis for the M.Sc. Degree (Moll, 1965) in the Botany Department, University of Natal, Pietermaritzburg.

The Upper Mgeni Catchment, an area of approximately 330 square miles (845 square kilometres), is 15 miles (25 km) northwest of Pietermaritzburg (Fig. 1).

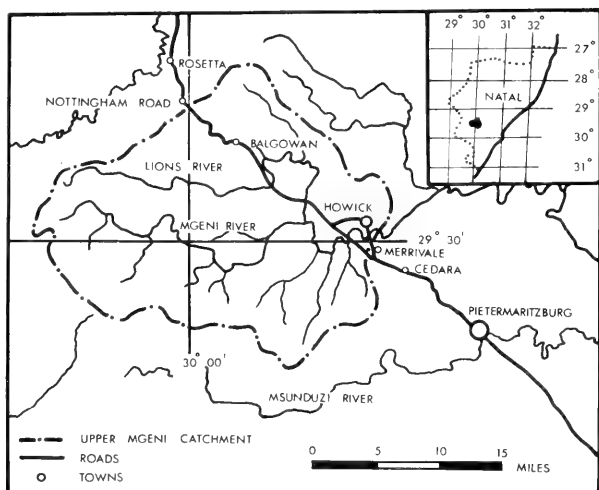


Fig.1. Location and drainage pattern of the Upper Mgeni Catchment, insert shows this area in Natal.

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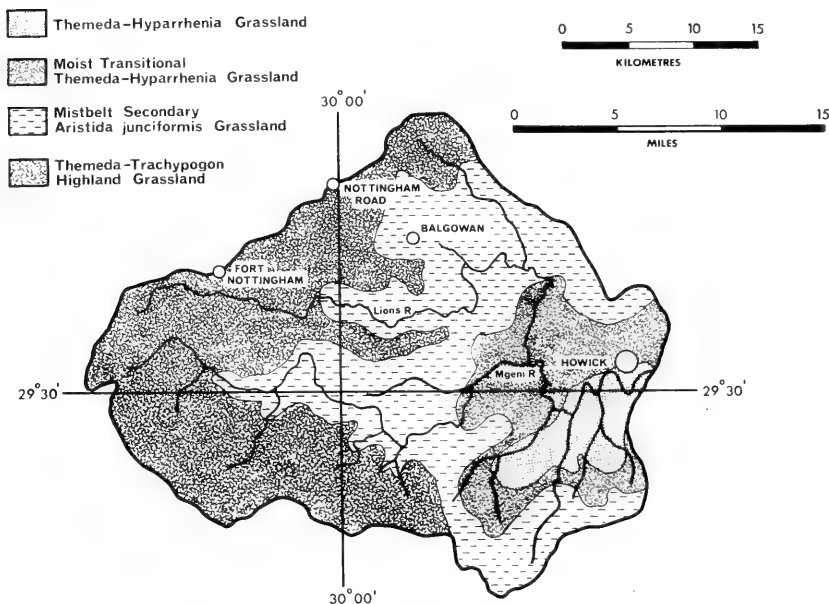


Fig. 2. The vegetation of the Upper Mgeni Catchment.

Four major vegetation types were distinguished in the area (Fig. 2), and their nomenclature follows that of Edwards (1967). Aspect and altitude were important factors in determining the extent of the vegetation types, which were as follows:—

- (i) *Themeda-Hyparrhenia* Grassland, covering approximately 21 square miles (54 square kilometres), below 3,500 ft. (1,069 m).
- (ii) Moist Transitional *Themeda-Hyparrhenia* Grassland covering approximately 42 square miles (108 square kilometres), between 3,000 and 4,000 ft. (914 and 1,219 m).
- (iii) *Themeda-Aristida* Grassland and Mistbelt Mixed *Podocarpus* Forest, covering approximately 112 square miles (287 square kilometres), between about 4,000 and 4,500 ft. (1,219 and 1,372 m).
- (iv) *Themeda-Trachypogon* Grassland and Mountain *Podocarpus* Forest, covering approximately 155 square miles (497 square kilometres), above about 4,500 ft. (1,372 m).

## GEOMORPHOLOGY AND SOILS

The geology of the area is simple, comprising near horizontal beds of sedimentary rocks of the Karroo System (du Toit, 1954). Ubiquitous in the area are innumerable dolerite dykes and sills, resulting in many boulder-strewn areas. The dolerite, being harder than the surrounding matrix, gives rise to such topographic features as hills and waterfalls.

The topography of the area (Fig. 3) is a series of rolling, grass-covered hills with occasional steep valleys and broad flat plains (Plate 1). The area is drained by the Mgeni and Lions Rivers which rise in large, permanent vleis above 4,000 ft. (1,219 m). Almost continuous terracettes (King, 1951), resembling contour paths, are a conspicuous feature of the steep grass-covered slopes.

Little data on the soils of the area were available, but, by extrapolation (van der Eyk in Edwards, 1967), the soils of the *Themeda-Hyparrhenia* Grassland type were considered partly leached types, whereas the remaining soils represent highly leached types.

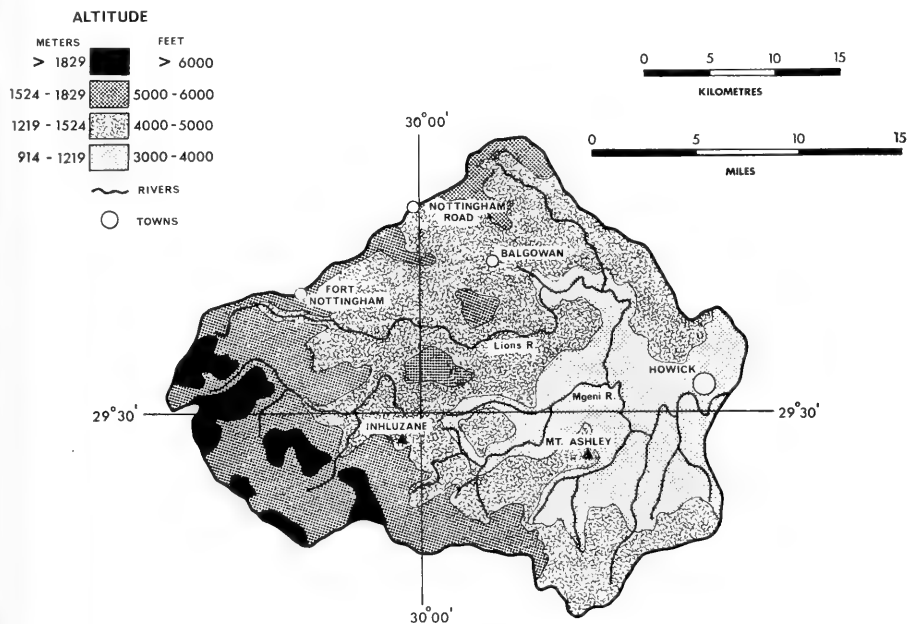


Fig. 3. Topographic map of the Upper Mgeni Catchment.



PHOTO 1. Looking north over the rolling, grass-covered hills and the flat river valleys.



PHOTO 2. A wind-blown *Protea multibracteata*. Note that only two old trees remain and that there is no sign of any young trees.

# CLIMATE

1. *Insolation.* The north-facing slopes are warmer, and consequently drier, than the cooler, more moist, south-facing slopes. This is illustrated by the presence of forest species on the south-facing slopes and their absence on north-facing slopes, except where there is additional soil moisture from springs.
2. *Temperatures.* Generally, the temperatures of the area are mild, averaging 13 to 16°C for the year. However, it is the extreme temperatures that are significant. Severe frost may occur throughout the Catchment (Weather Bureau, 1942 and 1954), while the highest maximum temperature recorded is a little above 40°C.
3. *Wind.* The southerly winds bring rain and fog during summer (October to March). Berg winds, which occur mainly from June to September, blow from the northwest and are hot and dry (Tyson, 1964). They occur at a time of year when the water stress for the vegetation is greatest. Winds may also cause some mechanical damage to woody species, occasionally uprooting trees and breaking branches (Plate 2).

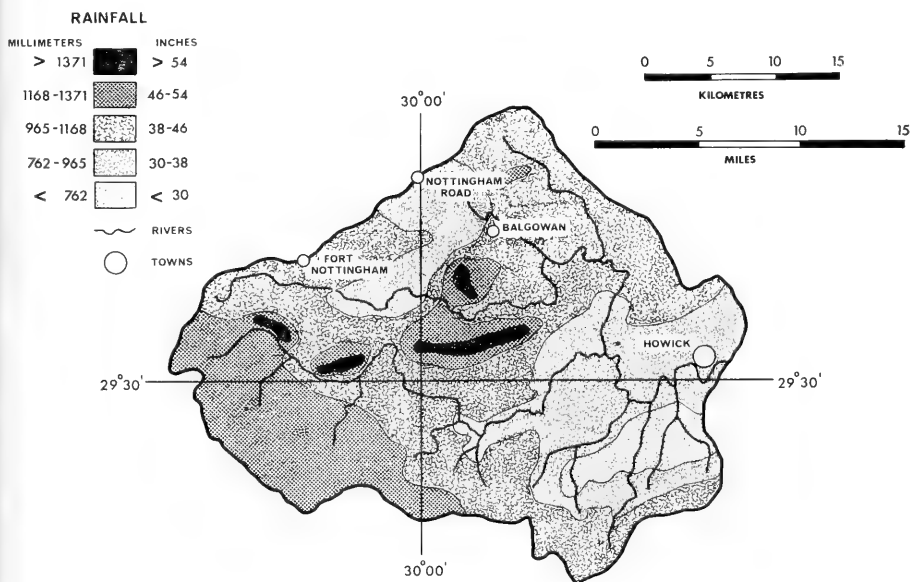


Fig. 4. Mean annual rainfall in the Upper Mgeni Catchment.

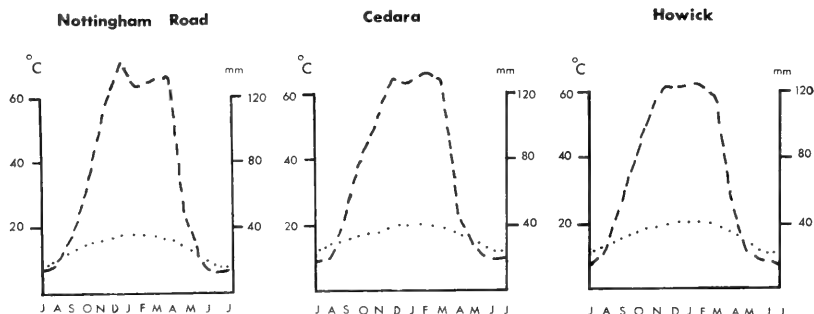


Fig. 5. Climatographs showing duration and intensity of wet and dry periods for three stations (dotted line is temperature; dashed line rainfall).

4. *Precipitation.* The Upper Mgeni Catchment is in the summer rainfall area. Data of mean annual rainfall from 37 stations (Rainfall Normals, 1939; Weather Bureau, 1954; and local farm records) were plotted onto a map and give some indication of the rainfall pattern over the area (Fig. 4). The catchment can be divided into four rainfall regions, which correspond remarkably well with the vegetation types.

Fog is an important source of precipitation as evidenced by the occurrence of forest patches on those slopes receiving most fog.

Hail, although only occurring occasionally, can be exceedingly destructive, causing extensive damage to woody plants in particular.

Snow occurs regularly once or twice a year above 5,000 ft. (1,524 m), but is fairly rare below this level. Snow is important as it brings moisture in an otherwise dry period. It also causes considerable mechanical damage to woody vegetation, particularly forest.

5. *Interaction of rainfall and temperature.* The diagrammatic method of Walter (1953) for plotting rainfall and temperature data provides an effective means of assessing intensity and duration of wet and dry periods. These diagrams show that all three stations have a mildly dry winter and a moist summer.

#### HISTORICAL BACKGROUND

An appreciation of the history of an area assists in interpreting the current vegetation patterning. The most important factors affecting the vegetation of the Upper Mgeni Catchment are the use of fire, and land utilization.

It is considered that fire in early spring was a natural factor (Bayer, 1953). But, with the settlement of the land autumn burning was initiated, resulting in

a change in grassland composition from mainly *Themeda*, to *Aristida* Grassland.

The system of land-use changed from extensive to semi-intensive as the country became settled by the Europeans. With man came his domestic stock which are selective grazers, choosing the palatable grasses such as *Themeda* and leaving the unpalatable species such as *Aristida*. This, therefore, had the same effect as autumn burning.

Since 1838 the indigenous forests have been exploited for their timber and most large trees have been removed from the forest patches.

## THE VEGETATION

### 1. SERAL VEGETATION

#### 1.1. *The Hydrosere*

1.1.1. *Vlei hydrosere*. Vleis, or marshy areas with a fluctuating water level, are most common above 4,500 ft. (1,372 m) where some are 100 acres (40 hectares) and more in area. In the larger vleis surface water is usually perennial (Plate 3), and in the wet season, when the water level rises, a much larger adjacent flat area is inundated.

Around most vleis there is a fairly distinct zonation of plant communities:

(a) Submerged aquatics are found where there are perennial pools. Common algae are species of *Spirogyra*, *Zygnema*, *Nitella* and *Cladophora*. The only submerged aquatic angiosperm found was *Lagarosiphon muscoides*.

(b) Partially submerged aquatic plants are the most common type. Dominant species are tussock and rhizomatous, perennial sedges and grasses, from two to four feet (0.6 to 1.2 m) high, such as *Scirpus fluitans*, *Cyperus denudatus*, *Carex* spp., *Leersia hexandra* and *Juncus exertus*. Occasionally, local consociates of *Phragmites communis*, up to nine feet (2.7 m) high, also occur. Other herbaceous plants are *Mentha aquatica*, *Geranium incanum*, *Cerastium arabis* and *Polygonum salicifolium*.

(c) The next community, on the outward zonation of vlei vegetation, is Sedge-Meadow. This is the most extensive community occurring on the area flooded in summer. Dominant plants are tussock and rhizomatous sedges up to three feet (0.9 m) high. In some areas certain grass species are also found. Common species are *Pycnus flavescens*, *P. macranthus*, *P. oakfortensis*, *Juncus effusus*, *J. oxycarpus*, *Scirpus macer*, *S. muricinus*, *Scleria welwitschii*, *Beckeropsis uniseta*, *Festuca caprina*, *Kyllinga melanospora*, *Fuirena pubescens*, *Pennisetum sphacelatum*, *Rhynchospora glauca*, *Fingerhuthia sesleriaeformis*, *Hemarthria altissima* and *Bulbostylis schoenoides*. In addition, there are numerous associated herbaceous species such as *Gerbera natalensis*, *Ranunculus multifidus*, *Senecio caudatus*, *Helichrysum* spp., *Urginea macrocentra*, *Verbena bonariensis*, *Kniphofia buchananii*, *Anoanthus breviflorus*, *Aponogeton junceus*, *Limosella africana*,



PHOTO 3. A large vlei with perennial water, fringed by partly submerged aquatics, such as *Scirpus fluitans* (rear) and *S. corymbosus* (sides and foreground.)



PHOTO 4. *Phragmites communis* forming a narrow fringe along a stream bank.



*Diclis reptans*, *Scilla* spp., *Trifolium* spp., *Drosera burkeana*, *Rhodohypoxis* spp., *Utricularia livida* and *Lobelia* spp.

(d) Between the Sedge-Meadow and the surrounding grassland there is sometimes a narrow zone of hygrophilous grasses. Common species are *Festuca caprina*, *Tristachya hispida*, *Poa binata*, *Koeleria cristata*, *Paspalum* spp., *Imperata cylindrica* and *Andropogon eucomis*. The last two usually occur on poorly drained soils.

1.1.2. *Stream Hydrosere*. Most streams are swiftly flowing and subject to frequent flooding, due to the seasonal nature of the rainfall. The boundaries between aquatics and the fringing vegetation are sharply defined, because of the rapid decrease in soil moisture content away from streams (Plate 4).

The zonation of plant communities is often indistinct, but the following types can be distinguished:—

(a) Submerged aquatics are mainly algae such as *Oedogonium* and *Batrachospermum*. Angiosperms, such as *Potamogeton pusillus* and *Lagarosiphon muscoides*, are rare. On rocks in rapids and waterfalls the highly specialized *Hydrostachys natalensis* thrives.

(b) Partly submerged aquatics are poorly represented, the most common being *Leersia hexandra*, *Scirpus fluitans*, *Cyperus textilis*, *Polygonum* spp., *Phragmites communis* and *Potamogeton thunbergii*.

(c) The stream bank communities below 4,000 ft. (1,219 m) comprise woody plants such as *Combretum erythrophyllum*, *Salix woodii*, *Diospyros lycioides* and *Acacia ataxacantha*, and may form patches of dense riverine bush up to 25 ft. (7.6 m) high. Above 4,000 ft. (1,219 m) *Leucosidea sericea*, *Passerina montana*, *Salix woodii*, *Diospyros lycioides*, *Cyathea dregei* and *Erica caffrorum* often form a scattered community 10 to 15 ft. (3.0 to 4.6 m) high.

Herbaceous species are similar throughout, the commonest being *Miscanthidium junceum*, *Phragmites communis*, *Kniphofia laxiflora*, *Juncus exertus* and *Zantedeschia aethiopica*. Above 4,500 ft. (1,372 m) additional species such as *Danthonia macowanii*, *Moraea spathulata* and *Gunnera perpensa* occur.

## 1.2. *The Lithosere*

1.2.1. *Succession on dry rock*. Initial invaders are crustose and foliose lichens. Higher plants are only able to invade these areas once there is sufficient soil for their roots. The soil usually accumulates in cracks and depressions. Common pioneers are *Pellaea viridis*, *Aristida junciformis*, *Rhynchelytrum setifolium*, *Heteropogon contortus*, *Rendlia altera* and *Michrochloa caffra*.

1.2.2. *Succession on moist rock*. On moist rock several seral stages can be recognized. Initial invaders are lichens, blue-green algae and bryophytes. The



PHOTO 5. One of the grass mats, comprised of *Styppichloa gynoglossa* and *Andropogon filifolius*, rolled back to show the mass of interlocked fibrous roots. The fern on the left is *Pellaea viridis*.



PHOTO 6. *Moraea spathulata* is one of the most common associated herbaceous species in the *Themeda-Trachypogon* Grassland.

next stage in the succession is the invasion of these pioneer communities by *Selaginella dregei* and other mat-forming angiosperms, such as *Rendlia altera*, *Michrochloa caffra*, *Bulbostylis caricoides*, *Styppeiochloa gynoglossa* and *Andropogon filifolius* (Plate 5). Numerous other herbaceous species invade these mats. In the wetter areas Sedge-Meadow species are common, and, in drier areas, common species are *Thesium costatum*, *Cyperus rupestris*, *Eragrostis racemosa*, *Scirpus falsus*, *Elyonurus argenteus*, *Euphorbia gueinzii*, *Brachystelma pygmaeum*, *Euryops dyeri*, *Hypoxis* spp., *Scilla* spp., *Crassula ramuliflora*, *Fimbristylis* spp., *Tulbaghia* spp., *Wurmbea kraussii* and *Zaluzianskyia pulvinata*.

1.2.3. On dolerite outcrops the soil between the boulders is fairly deep, supporting a good grass cover. The dominant species is *Themeda triandra*. Other associated species are *Tristachya hispida*, *Andropogon filifolius*, *Harpachloa falx*, *Elyonurus argenteus*, *Festuca costata*, *Heteropogon contortus*, *Helictotrichon turgidulum*, *Cymbopogon validus*, *Aristida junciformis* and *Hyparrhenia hirta*. The last two species are characteristic of secondary disturbance. Common associated herbs are *Veronia hirsuta*, *Rhynchosia minima*, *Gladiolus* spp., *Senecio* spp., *Dierama* spp., *Lotononis corymbosus*, *Scilla natalensis*, *Gerbera natalensis*, *Acalypha peduncularis*, *Aster* spp., *Watsonia meriana*, *Helichrysum* spp., *Vigna vexillata*, *Pelargonium* spp., and *Nemesia* spp.

Where the boulders offer protection from fire, woody species such as *Passerina montana*, *Erica caffrorum*, *Asparagus* spp., *Athanasia acerosa*, *Rubus ludwigii* and *Chrysocoma tenuifolia* grow.

## 2. CLIMAX VEGETATION

Two main climax vegetation types are represented.

### 2.1. Grassland communities

Grassland is the most extensive community in the Upper Mgeni Catchment, covering approximately 85% of the total area. However, over most of the area the average annual rainfall exceeds 900 mm, sufficient, in the absence of fire, to support a forest climax. Fire halts the succession at the grassland stage.

#### 2.1.1. Primary Grassland

The following primary grassland types are found:—

##### (a) *Themeda-Hyparrhenia* Grassland

The *Themeda-Hyparrhenia* Grassland is equivalent to the Tall Grassland of Pentz (1945) and the Southern Tall Grassveld of Acocks (1953). It occupies approximately 21 square miles (53 square km), below 3,500 ft. (1,069 m), and is confined to the relatively dry Merrivale Basin south of the Midmar Reservoir. The country is fairly flat and a characteristic feature is the presence of widely

scattered, flat-topped *Acacia sieberana* trees up to 30 ft. (9 m) high, though many have been felled.

The average rainfall is less than 860 mm a year and the average temperature is about 16·0° C. Soils vary from unleached to partly leached types.

Three strata are represented and important species of the upper stratum are *Themeda triandra* and *Hyparrhenia hirta* which form a dense community about four feet (1·2 m) high, sometimes with *Cymbopogon plurinodis* being locally common. Mid-stratum grasses are *Tristachya hispida*, *Eragrostis capensis*, *E. curvula*, *Heteropogon contortus* and *Brachiaria serrata* which form an almost continuous layer about two feet (0·6 m) high. In addition, *Eragrostis racemosa* and *Cynodon dactylon* form a discontinuous layer of short grasses less than one foot (0·3 m) high.

(b) *Moist Transitional Themeda-Hyparrhenia Grassland*

In the Upper Mgeni Catchment there is a fairly large ecotonal area between the upper boundary of the *Themeda-Hyparrhenia* Grassland and the lower boundary of the *Themeda-Aristida* Grassland, at between 3,000 and 4,000 ft. (914 and 1,219 m) altitude. This area is occupied by the Moist Transitional *Themeda-Hyparrhenia* Grassland and is approximately 42 square miles (106 square km) in extent.

The average annual rainfall is between 760 and 960 mm and the soils are partly leached to leached.

The grassland is of mixed composition. The most common species are *Themeda triandra* and *Hyparrhenia hirta*. Other fairly common species are *Tristachya hispida*, *Eragrostis capensis*, *E. racemosa*, *E. curvula*, *Sporobolus capensis*, *Aristida junciformis*, *Monocymbium ceresiiforme*, *Harpechloa falx* and *Heteropogon contortus*.

On rocky slopes, where there is greater protection from fire, *Aloe candelebrum* Savanna may develop. Other associated woody plants are *Greyia sutherlandii*, *Ziziphus mucronata*, *Ehretia rigida*, *Maytenus heterophylla*, *Cussonia spicata* and *Rhus pentheri*.

(c) *Themeda-Aristida Grassland*

The *Themeda-Aristida* Grassland is equivalent to the Grassland of the Temperate Forest Region of Pentz (1945), and Acocks's (1953) *Themeda* Veld of the Natal Mistbelt. It is one of the two most extensive grassland communities in the area, occupying approximately 112 square miles (290 square km) between 4,000 and 4,500 ft. (1,219 and 1,372 m). The terrain is fairly rugged, the mean annual rainfall exceeds 960 mm, and the soils are leached.

Two strata are represented and the commonest species in the upper continuous layer, which is about two feet (0·6 m) high, are *Themeda triandra* and *Aristida junciformis*. Other species are *Tristachya hispida*, *Monocymbium ceresiiforme*, *Harpechloa falx*, *Eragrostis capensis*, *Trachypogon spicatus*,

*Andropogon amplexans*, *A. filifolius*, *Alloterospis semialata*, *Festuca scabra*, *F. caprina*, *Panicum ecklonii*, *Loudetia simplex*, *Heteropogon contortus* and *Setaria nigrirostris*. The species *Rendlia altera*, *Eragrostis racemosa* and *Microchloa caffra* form a discontinuous lower stratum.

(d) *Themeda-Trachypogon* Highland Grassland

The *Themeda-Trachypogon* Highland Grassland is equivalent to the Highland Sourveld of Pentz (1945) and Acocks (1953). It is the most extensive community in the area occupying approximately 155 square miles (401 square km.), above 4,500 ft. (1,372 m). The country is fairly flat, the mean annual rainfall exceeds 960 mm, and the soils are highly leached.

Two strata are represented and the dominant species in the upper continuous layer, which is about two feet (0.6 m) high, are *Themeda triandra* and *Trachypogon spicatus*. Other fairly common species are *Tristachya hispida*, *Monocymbium ceresiiforme*, *Andropogon amplexans*, *A. filifolius*, *Festuca scabra*, *F. caprina*, *F. costata*, *Loudetia simplex*, *Sporobolus centrifugus* and *Danthonia stricta*. A short, discontinuous, lower stratum is formed by *Eragrostis racemosa*, *Microchloa caffra*, *Rendlia altera* and *Stiburus alopecuroides*.

In a few isolated areas *Protea multibracteata* Savanna occurs, but this relic community shows little sign of regeneration.

Numerous forbs also grow in the grassland and these may be rare, or locally common, constituents (Plate 6). Most species flower in spring and early summer, their evolutionary development being related to fire and grass competition (Bews, 1918; Bayer, 1953). The majority are thus geophytes and hemicryptophytes, their buds below, or at, the soil surface escaping fire-damage.

The species involved are numerous and many belong to the families Cyperaceae, Liliaceae, Amaryllidaceae, Iridaceae, Orchidaceae, Leguminosae, Euphorbiaceae, Labiatae, Acanthaceae, Rubiaceae and Compositae.

### 2.1.2. *Secondary Grassland*

Most of the grassland in the Upper Mgeni Catchment is secondary, due to cultivation and to recent veld management practices. The following secondary communities occur:—

(a) *Aristida junciformis* Grassland, between 4,000 and 4,500 ft. (1,219 and 1,372 m), has resulted from autumn, or early winter, burning and selective grazing (Plate 7).

(b) *Hyparrhenia hirta* Grassland, below 4,000 ft. (1,219 m), is a consequence of selective grazing, veld disturbance and old cultivation.

(c) *Eragrostis-Sporobolus* Grassland occurs throughout the area, usually in small isolated patches where there has been excessive trampling.

(d) *Festuca costata* Grassland, above 5,000 ft. (1,524 m), occurs in isolated patches where there has been continuous grazing by sheep and annual winter burning.



PHOTO 7. Selective grazing and autumn burning results in the invasion of the grassland by *Aristida junciformis*.



PHOTO 8. Fire damage to Mountain *Podocarpus* Forest.

- (e) *Athanasia acerosa* Scrub, between 4,500 and 5,500 ft. (1,372 and 1,674 m), is found in isolated areas where in the past the veld was overgrazed by sheep.
- (f) *Rubus cuneifolius* Scrub is found throughout the area in small patches where the seed has been deposited by birds or man. It is a vigorous plant that is increasing in extent.
- (g) *Cynodon dactylon* Grassland is found in areas where stock congregate, possibly a combined trampling, and increased nitrogen content effect.

## 2.2. Forest communities

Forest is the climatic climax vegetation between 4,000 and 6,000 ft. (1,219 and 1,829 m) and usually occurs in patches on mesic, steep, south-facing slopes. These patches have been exploited for timber since 1838, mainly for *Podocarpus* spp. This exploitation, combined with the destruction of the forest margins by grass fires (Plate 8), has caused the forests to diminish rapidly in size.

### 2.2.1. Seral woody forest communities

Seral woody forest communities only develop where there is some protection from fire (Plate 9). Post-grassland stages are represented by tall grass and shrub communities, such as:

- (i) *Hyparrhenia* Mixed Tall Grassland Communities. *Hyparrhenia aucta* and occasionally *Cymbopogon* spp. or *Miscanthidium capense*, are the usual tall tussock grass species, with *Leonotis leonurus*, *Pteridium aquilium*, *Veronica corymbosa*, *Rubus ludwigii*, *Watsonia densiflora* and *Dierama pendula* being associated herbs.

Where there is some measure of protection from fire, woody plants, such as *Leucosidea sericea*, *Buddleia salviifolia* and *Maytenus heterophylla*, are able to invade.

- (ii) *Leucosidea sericea* Scrub. This scrub is usually found above 4,500 ft. (1,372 m) on moist soils along river banks, in damp depressions and on boulder-strewn slopes. The community comprises a pure stand of *Leucosidea* and may be fairly open or very dense.

(iii) *Mixed Woody Communities*. These are particularly common on forest margins and, in the ectone region of the Moist Transitional *Themeda-Hyparrhenia* Grassland, on fire protected sites. Below 4,000 ft. (1,219 m) common tree species, up to 35 ft. (10·6 m) high, are *Ochna atropurpurea*, *Canthium mundianum*, *Ziziphus mucronata*, *Brachylaena elliptica*, *Dais continifolia*, *Maytenus heterophylla*, *Hippobromus pauciflorus*, *Cassine* spp., *Rhus pentheri* and *Cussonia spicata*. Above 4,000 ft. (1,219 m) common tree species are *Buddleia salviifolia*, *Leucosidea sericea*, *Heteromorpha trifoliata* and *Choristylis rhamnoides*.

Lianes such as *Dalbergia obovata*, *Capparis transvaalensis*, *Rhoicissus*



PHOTO 9. *Leucosidea sericea* (left) and *Podocarpus latifolius*, which are forest species, are able to grow on sites protected from fire in the *Themeda-Trachypogon* Grassland.



PHOTO 10. The mosaic of tree canopies gives an indication of the mixed nature of Mixed Mistbelt *Podocarpus* Forest.



*tridentata*, *R. rhomboidea*, *R. tomentosa*, *Acacia ataxacantha*, *Senecio* spp., *Scutia myrtina* and *Combretum* sp. nov., are fairly common in this community, particularly below 4,500 ft. (1,372 m), and are important as they increase the density of shade.

The effect of these seral communities is to provide a habitat suitable for the invasion of climax forest tree species. Some of the first to invade are *Cryptocarya woodii*, *Rapanea melanophloeos*, *Scolopia zeyheri*, *Halleria lucida*, *Podocarpus latifolius*, *Maytenus acuminata*, *Vepris undulata*, *Apodytes dimidiata*, *Fagara davyi*, *Trimeria rotundifolia*, *Pittosporum viridiflorum* and *Allophylus dregeanus*.

### 2.2.2. Climax forest

Two relatively distinct climax forest types occur in the area.

(a) Mistbelt Mixed *Podocarpus* Forest occurs in patches on south-facing slopes, in the *Themeda-Aristida* Grassland region. The species composition is very mixed and the canopy height varies from 45 to 70 ft. (14 to 21 m) and the forest has five strata (Plate 10). Structure is best shown by a profile diagram (Fig. 6). The upper closed canopy is occasionally pierced by taller growing, emergent species from 70 to 100 ft. (21 to 30 m) high. Species include *Cussonia chartacea*, *Cryptocarya myrtifolia*, *Podocarpus falcatus* and *Ptaeroxylon obliquum*. Common canopy species, which are 45 to 70 ft. (14 to 21 m) high, are *Calodendrum*

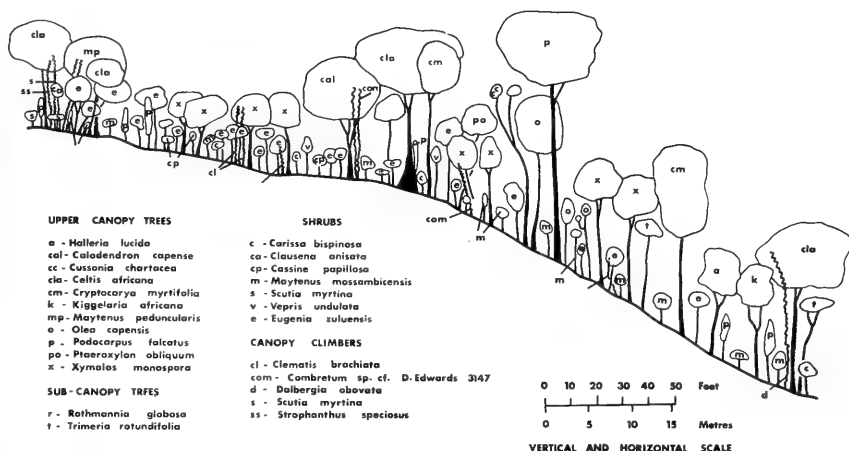


Fig. 6. Profile diagram of Mistbelt Mixed *Podocarpus* Forest on a south-facing slope (belt 300 x 25 ft.).

*capense*, *Celtis africana*, *Podocarpus latifolius*, *Fagara davyi*, *Prunus africanus*, *Podocarpus henkelii*, *Combretum kraussii*, *Xmyalos monospora*, *Kiggelaria africana*, *Halleria lucida*, *Cryptocarya woodii*, *Scolopia mundii*, *Vepris undulata*, *Ficus craterostoma*, *Ekebergia capensis*, *Scolopia zeyheri*, *Apodytes dimidiata*, *Linociera foveolata*, *Rhus chirindensis*, *Maytenus peduncularis*, *Ilex mitis* and *Ocotea bullata*.

Below the upper canopy is a discontinuous subordinate tree layer, 30 to 40 ft. (9 to 12 m) high. This is best developed where the canopy is not particularly dense and species such as *Trimeria rotundifolia*, *Dombeya tiliacea*, *Rothmannia capensis*, *R. globosa*, *Canthium mundianum*, *Pavetta lanceolata* and *Tricalysia lanceolata* occur. Beneath this stratum is another layer of small trees and shrubs, from 6 to 20 ft. (2 to 6 m) high. Common species are *Eugenia zuluensis*, *Maytenus mossambicensis*, *Carissa bispinosa*, *Canthium ciliatum*, *Dovyalis rhamnoides*, *D. zeyheri*, *Diospyros whyteana*, *Peddiea africana*, *Maytenus undata*, *Rinorea angustifolia*, *Englederodaphne pilosa* and *Cassine papillosa*.

In the forest field layer are herbaceous plants up to 4 ft. (1.2 m) high. Wide-spread species are *Oplismenus hirtellus*, *Brachypodium flexum*, *Cyperus albostratus*, *Stipa dregeana*, *Selaginella kraussiana*, *Panicum* spp., and *Diets vegeta*. Common ferns in this layer are *Polystichum amnifolium*, *Cyrtomium caryotideum*, *Adiantum thalictroides* and *Asplenium aethiopicum*.

Lianes are frequent, especially where the canopy has been disturbed. Species are numerous and include *Dalbergia obovata*, *Scutia myrtina*, *Combretum* sp. nov., *Rhoicissus* spp., *Cnestis natalensis*, *Clematis brachiata*, *Strophanthus speciosa*, *Entada spicata* and *Secamone gerrardii*.

The profusion of epiphytes is a characteristic feature of this type. Angiosperms such as *Peperomia reflexa*, *Streptocarpus verecundus*, *Mystacidium* spp. and *Polystachya* spp., and ferns and bryophytes such as *Pleiopeltis* spp., *Asplenium* spp., *Brachymenium pulchrum*, *Leptodon smithii* and *Entodon dregeanus*, occur most frequently on old trees.

(b) Mountain *Podocarpus* Forest occurs in patches on south-facing slopes in the *Themeda-Trachypogon* Highland Grassland region. This forest is shorter than Mistbelt Mixed *Podocarpus* Forest, having a canopy height of 45 to 60 ft. (14 to 18 m). The forest does not have a large variety of species present and only three strata can be recognized. Structure is shown in a profile diagram (Fig. 7). The continuous upper canopy is rarely pierced by emergent trees. *Podocarpus latifolius* is usually the dominant species, but other common trees are *Euclea crispa*, *Halleria lucida*, *Olinia emarginata*, *Linociera foveolata*, *Fagara davyi*, *Celtis africana*, *Scolopia zeyheri*, *Apodytes dimidiata* and *Prunus africanus*.

Below the canopy there is no definite, shorter tree layer and woody plants present vary greatly in density and in height, from 9 to 40 ft. (3 to 12 m). Common

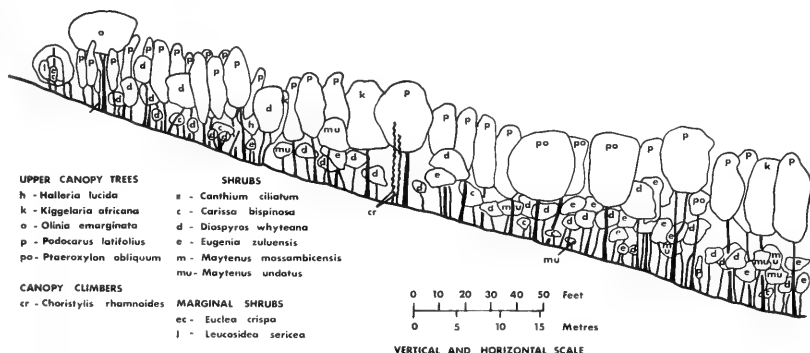


Fig. 7. Profile diagram of Mountain Podocarpus Forest on a southeast-facing slope (belt 300 x 25 ft.).

species are *Diospyros whyteana*, *Eugenia zuluensis*, *Canthium ciliatum*, *Dovyalis lucida*, *Maytenus mossambicensis*, *M. undata* and *Carissa bispinosa*.

The herbaceous field layer is more uniform than in Mistbelt Mixed Podocarpus Forest, with *Brachypodium flexum* and *Oplismenus hirtellus* forming a dense sward.

Lianes are infrequent and species occurring are *Choristylis rhamnoides*, *Clematis brachiata*, *Scutia myrtina*, *Cassinopsis ilicifolia* and *Strophanthus speciosa*.

Epiphytes are not numerous and comprise *Peperomia reflexa*, *Streptocarpus* spp. and *Mystacidium* spp.

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#### BOOK REVIEW

"SOIL BIOLOGY" edited by A. Burges and F. Raw. x plus 582 pages with 113 figures and 76 tables. Academic Press, London and New York 1967. £7.

The soil biologist can hardly do without this book which gathers together specialist information on botanical, zoological and microbiological problems and research in the specialist field of soil biology. Certainly the book will also be invaluable to advanced microbiology students.

Prof. A. Burges, the Vice-Chancellor of the New University of Ulster, gives an opening chapter on the soil system which is a concise summary of the habitat for the organisms dealt with by other specialists. The Hartley Botanical Laboratories at the University of Liverpool which were previously headed by Prof. Burges have long played a leading role in soil and litter microbiological research. Prof. Burges also contributes a chapter on organic matter decomposition.

The co-editor, F. Raw, was responsible for the eight chapters devoted to the soil fauna. Botanists will welcome these as, in the normal course of events, zoological literature is not readily available to them. Any biological problem, of course, presents a critical balance between plants, animals and micro-organisms in the same environment.

Each of the 17 chapters is contributed by a leading specialist in the group concerned—N. Walker of Rothamsted presents a chapter on the ever increasingly important subject of soil micro-organisms and plant protection chemicals, dealing with the microbial decomposition of herbicides and pesticides.

Mr. D. B. Cragg of the Nature Conservancy, Merlwood Research Station, Lancashire, is to be congratulated on initiating the production of this book.

There is an extensive Author Index as also a Subject Index, both of which should prove extremely valuable to the reader. The literature references accompanying each article are very comprehensive. The exact title of the article, however, is always of great help to the reader and this unfortunately is not provided.



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